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Anticipate And Pre-Empt

Controllability Trends And Looking Glasses

The TRIZ ‘Controllability’ evolution trend dissects the discontinuous evolution of the control of systems into three distinct stages – a first stage in which the system is directly controlled; a second evolution stage in which the controlling action is conducted through some kind of intermediary (e.g. use of relays in electrical circuits); and then a third stage in which some form of system feedback is added and used to influence how the system is controlled. Thanks to the emergence of extremely low-cost semi-conductor technologies, the world has seen many, many systems evolve to this third stage in the last thirty years. What we could see happening when we were putting together an updated list of trends for the Hands-On books was that a fourth discontinuous evolution stage had emerged since the three-stage controllability definition found in the original TRIZ literature. In the book, this fourth stage was simply referred to as ‘intelligent feedback’ (Figure 1). At the time, this was the only truly generic statement that could be made about the evolution of control systems. The word ‘intelligent’, of course, could and should be taken to mean a whole bunch of different things. In the main, it has been interpreted as the incorporation of some form of adaptive capability. A control system that is capable of recognizing and accommodating the different characteristics of two different individual operators, for example, would be a good example of a control system containing a degree of intelligence. Likewise ‘fuzzy logic’ or ‘learning’ control systems also represent evolution jumps to the fourth stage.

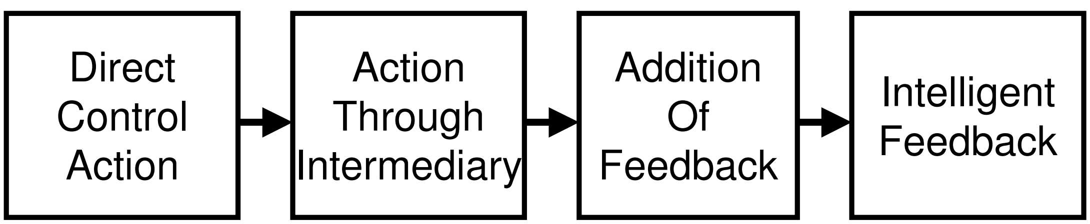


Figure 1: Controllability Trend From Hands-On Systematic Innovation

In the forthcoming ‘TRIZ for Software Engineers’ book, the Controllability trend is re-formulated somewhat, and in addition to an ‘adaptive’ or ‘intelligent’ stage also adds a new ‘final’ discontinuous jump, this time to a ‘self-adapting, autonomous or autopoeitic’ state. Software-based control systems, in other words, can be seen to be evolving to a stage of self-authoring, self-updating, self-repairing or self-replicating capability.

In the business context, the controllability trend is generally speaking again interpreted slightly differently; containing three discontinuous stages – no-feedback, to one-way-feedback to two-way feedback. It uses this form as, again generally, the control issues at stake generally involve the communication and interaction between people. It is one of the more important business trends as there are still many businesses (or parts within businesses) where the system may be seen to still be at the first or second stage of the trend. It is also important in that it can (and again ‘should’) be applied in many different ways. It can thus be applied to think within the organization at interpersonal or interdepartmental or interdivisional control, or it can be applied with an external perspective, looking at B2B or B2C or any other configuration of communication links between the business and the outside world.

Stephen Haeckel's book 'Adaptive Enterprise' (see review in Issue 33 of the e-zine) is essentially a book about the Dynamization, Action Co-ordination and Controllability trends in their business context. The main theme of the book is the need for organizations to shift from so-called 'make-and-sell' business models to what Haeckel describes as 'sense-and-respond' ways of doing business. Or rather that should be 'need if the market is a turbulent and rapidly changing one'. The most compelling case study in the book is an Australian bank. It is compelling because the financial sector is extremely competitive and different financial institutions find it increasingly difficult to discriminate their offerings from those of their competitors. By shifting from 'make-and-sell' (i.e. 'these are our range of financial products, take them or leave them') to 'sense-and-respond', the bank effectively moved from the first to the second stage of the Controllability trend – reaching a stage where they created a capability for adaptation that allowed a market need for a new financial product to be sensed and responded to in a 24 hour timeframe.

Perhaps because the book struggled to find many other convincing cases of organizations making the shift from make-and-sell to sense-and-respond, Haeckel only very briefly mentions a third discontinuous evolution stage. He did notice, however, that some organizations were attempting to go beyond mere 'sense-and-respond' and were actively trying to 'anticipate-and-pre-empt' the needs of their current and future customers. Although never formally plotted in the book, the trend observed by Haeckel looks something like the discontinuous trend pattern illustrated in Figure 2.

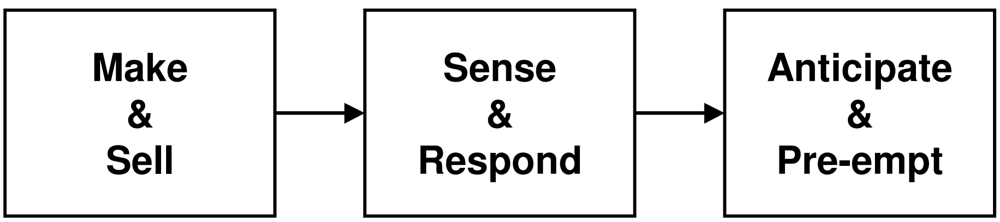


Figure 2: Emerging Business 'Controllability' Discontinuous Evolution Trend

In many ways, of course, this trend sounds and looks obvious. Doesn't, in fact, every organization attempt to do precisely that job of anticipating and pre-empting future customer requirements? Yes and no. Yes, in theory, they do. But then no, in practice, the tools available for any company to do the job effectively are not widely available. That plus the fact that most managers tend to be much happier in the make-and-sell mind-set than in either of the more advanced controllability stages. The full suite of other TRIZ trends, of course, is there to help enterprises to do precisely that 'anticipate and pre-empt' job. As we all know, the TRIZ trends very efficiently predict the emergence of the digital camera, or cell-phones, or cell-phones with cameras, or cell-phones with cameras and GPS, and so on.

Whether or not we deem it to be obvious, what Haeckel's book does is cause us to reflect on the relevance of 'anticipate and pre-empt' in a technical as opposed to business sense. The essential discontinuity present in 'anticipate and pre-empt' relative to the preceding 'sense-and-respond' stage is the shift from acting on existing information to acting on things that haven't happened yet. It is a shift, in other words, from acting on the past to acting on the future.

Again we see a discontinuous shift with considerable relevance to the design of control architectures for technical systems. Again too it is not a new shift – the idea of 'feed-forward' for example is something that has been around conceptually for almost as long as digital control systems have existed. It is however, a shift that is not often explicitly discussed. In retrospect, even though this author was first involved in the design of an 'anticipate and pre-empt' control system design in the late 1980s, the idea was not included either explicitly or implicitly when the controllability trend was being written up for the Hands-On book. The 'idea' here being that of creating a control system architecture possessing 'future-predicting' capabilities. It is in many ways simply yet another interpretation of the 'intelligent feedback' stage of the Figure 1 trend. The main point of this article, though, is to encourage users of the Controllability trend to be thinking about time – and particularly time that hasn't happened yet ('future time') – when thinking about what 'intelligent feedback' might mean as it gets translated it from general trend to something with specific relevance to a specific system under examination.

In Haeckel's business context, 'anticipate and pre-empt' is principally interpretable in terms of weeks, months or possibly years. Such are the time frames that business generally speaking operates in. In the context of control systems for technical systems, however, the interpretation of 'future time' is more likely to be measured in minutes or seconds or fractions of seconds.

Although in many ways 'obvious' the trend towards building future-time into a control system few technical or business systems have successfully bridged the discontinuity between feedback based on past information and feedback based on something that hasn't happened yet. The main reason behind this is probably largely due to the fact that reliable prediction of what might happen even a few milliseconds into the future requires not only a very deep understanding of what has happened in the past, but the uncovering of patterns from the past that act as reliable signposts to the future. A great example of the depth and breadth of knowledge required to anticipate and pre-empt the future can be found in Malcolm Gladwell's new book 'Blink'. In the book, Gladwell describes the evolution of a heart-attack anticipation system developed at Cook County hospital in Chicago. One of the biggest problems for a doctor is diagnosing whether a patient suffering from chest pains is about to have a heart attack. The problem is a complex one because of the myriad factors that could influence the decision – medical history, family, job, weight, age, sex, whether the patient smokes, etc. The book, describes the analysis of thousands and thousands of case studies and the gradual emergence of a heart-attack anticipation algorithm that now out-performs the diagnostic capabilities of even the best doctors. The point being that, without the knowledge of those thousands and thousands of historical cases, there is no way that the anticipatory algorithm could have been formulated.

The Cook County case is a specific example of a generalizable picture: reliable future-time intelligent feedback systems require significant historical data in order to establish what factors happening now will influence what a system will do in the future. Here is the discontinuous evolution jump that has to be made if a system – technical or business – is to successfully jump beyond the simple 'feedback' stage. Difficult as it may be to make that jump, at least the trend can serve as a solid indicator of the directions in which we should be looking to evolve what we currently do.

References

1) Haeckel, S.H., 'Adaptive Enterprise: Creating And Leading Sense-And-Respond Organizations', Harvard Business School Press, 1999.
2) Gladwell, M., 'Blink: The Power Of Thinking Without Thinking', Allen Lane/Penguin, London, 2005.

The Red Queen Principle

"no-one can convince me, we aren't gluttons for our doom"
Indigo Girls, Prince Of Darkness

It seems to be an inherent human trait that we all seek a position of optimum comfort or optimum stability. The trait, for some reason, seems to become more exaggerated within organizations. Managers, engineers and scientists alike tend towards achieving an empty in-tray, a blank problem log-sheet, etc. Especially in a 'continuous improvement' working environment, of course, we all know that the in-tray can never be empty, and that even if there ever were that magical 'no-more-problems' moment, there are still a host of hidden issues waiting to jump out on us. A little known North American Indian saying talks about how everyone has 83 problems. The point of the saying is that no matter how strong our drive to get to the zero-problem goal, we will never get there. Solve one problem, in other words, and another is bound to appear so that our list of 83 is maintained. Nevertheless, the urge to reach the optimum comfort position remains with us.

The Red Queen Principle has much to say about this urge for comfort and stability. The Principle comes from Lewis Carroll's Alice In Wonderland via an evolutionary biologist (Reference 1). In Lewis Carroll's version, the Red Queen states 'in this place it takes all the running you can do, to keep in the same place.' The Principle is usually stated in biological circles as follows:

for an evolutionary system,
continuing development is needed just in order to maintain its fitness
relative to the systems it is co-evolving with

In its biological context, it may be observed that, since every improvement in one species will lead to a selective advantage for that species, variation will normally continuously lead to increases in fitness in one species or another. However, because different species are co-evolving, improvement in one species implies that it will get a competitive advantage on the other species, and thus be able to capture a larger share of the resources available to all. This means that fitness increase in one evolutionary system will tend to lead to fitness decrease in another system. The only way that a species involved in a competition can maintain its fitness relative to the others is by in turn improving its own design.
The most obvious biological examples of the effect are the evolutionary 'arms races' between predators and prey. In these arms races, the only way predators can compensate for a better defense by the prey (e.g. antelope running faster) is by developing a better offense (e.g. cheetahs running faster). In this case we might consider the relative improvements (running faster) to be also absolute improvements in fitness, albeit, the ability to run faster will ultimately emerge at the expense of some other abilities – e.g. endurance in the case of the cheetah.

The example of trees shows that in some cases the net effect of an 'arms race' will also lead to an absolute decrease in fitness. Trees in a forest are normally competing for access to sunlight. If one tree grows a little bit taller than its neighbours, it can capture part of their sunlight. The drive for tallness in one species of tree produces an evolutionary pressure on other trees in turn to grow taller, in order not to be overshadowed. The net effect is that all trees tend to become taller and taller. At the same time, however they will still gather on average just the same amount of sunlight, while spending much more resources in order to sustain their increased height. Without devoting more resources to a larger root structure, for example, the tall tree will be much more vulnerable to adverse effects from winds and storms. This is an example of the problem of sub-optimization; optimizing access to sunlight for each individual tree does not lead to optimal performance for the forest as a whole. So, in sum, in a competitive world, relative progress ('running') is necessary just for maintenance ('staying put').

In its business context, the Principle implies not just that businesses have to keep running to stay put, but that ultimately, all the running they have done will lead them down an evolutionary cul-de-sac to the plateau of an s-curve.

Also in the business context, the Red Queen Principle is strongly related to the Peter Principle (Reference 2). The original principle states that *in a hierarchically structured administration, people tend to be promoted up to their "level of incompetence"*. In its more generalized form, it may be re-stated as:

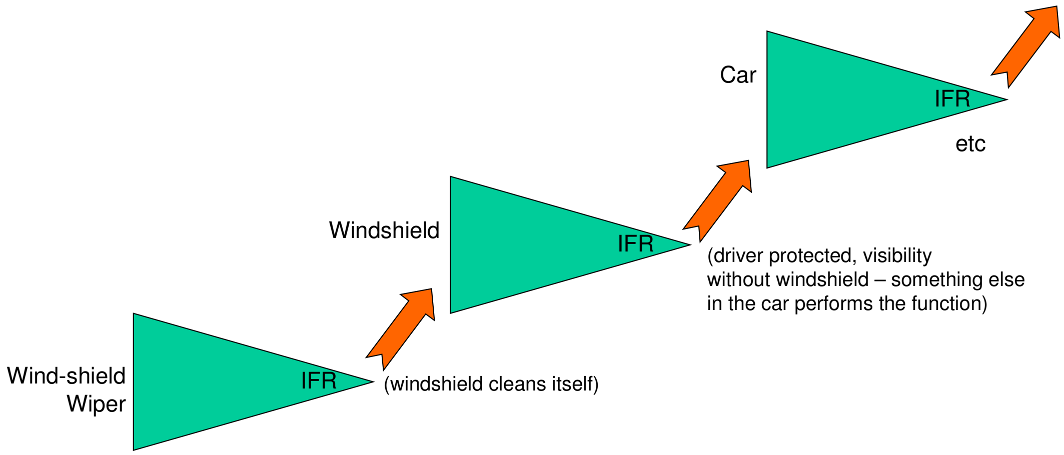
systems tend to develop up to the limit of their adaptive competence

The principle is based on the observation that employees are gradually promoted up an organizational hierarchy as they prove their competence at each given level. This process of climbing up the hierarchical ladder continues until the employee reaches a position where he or she is no longer competent. At that moment the process typically stops, since the established rules of bureaucracies make that it is very difficult to 'demote' someone to a lower rank, even if that person would be much better fitted and more happy in that lower position. The net result is that most of the higher levels of a bureaucracy will tend to become increasingly filled by incompetent people, who got there because they were quite good at doing a different task than the one they are now expected to do.

The evolutionary generalization of the principle is less pessimistic in its implications, since evolution lacks the bureaucratic inertia that pushes and maintains people in an unfit position. But what will certainly remain is that systems confronted by evolutionary problems will quickly tackle the easy ones, but tend to get stuck in the difficult ones. The 'better' (more fit, smarter, more competent, more adaptive) a system is, the more quickly it will solve all the easy problems, but the more difficult the problem will be it finally gets stuck in. Getting stuck here does not mean 'unfit', it just means reaching a limit of competence, and thus having great difficulty advancing any further. This is the equivalent of the tall tree, and the tree analogy helps explain why even the most complex and adaptive species (such as ourselves, humans) are always still 'struggling for survival' in their niches as energetically as are the most primitive organisms such as bacteria. If ever a species would get control over all its evolutionary problems, then the Red Queen Principle will always make sure that new, more complex problems would arise (83 of in the case of North American Indian folklore), so that the species would continue to balance on the border of its domain of incompetence.

The Red Queen Principle also connects us to the TRIZ Ideal Final Result concept. At first it may appear that the two things are in conflict with each other – one stating that we run to stay still and ultimately lose anyway; the other stating that systems will ultimately evolve to an 'ideal' end state. In order to resolve this conflict we need to consider how both statements might be true at the same time. As is often the case in such cases, an answer comes through hierarchical thinking: Take the oft-used case of the windshield-wiper. One day, whether the wind-shield wiper manufacturers like it or not, the IFR wiper will appear –

most likely, the windshield will clean itself and hence will take over the function previously performed by the wiper blades. But, take the story a step further, and we will also see that the windshield will also inevitably evolve towards its ideal final result state. Its function, too, will ultimately be taken over by something else at an even higher level in the automobile system hierarchy. The 83 problems, in other words, will never disappear; merely migrate to ever-higher hierarchical levels.



References

1) Van Valen, L.,'A New Evolutionary Law', *Evolutionary Theory* 1, pp1-30, 1973.
2) Peter, L.J., Hull, R., 'The Peter Principle', Souvenir Press, 1969.

Humour – Trimming in extremis

Switch on the TV in any country outside the US and sooner or later you are going to come across a programme or a film in which the speech has been dubbed from the original language. For the most part, provided you don't watch the lips too closely, the presence of dubbed speech can be reasonably invisible. Not so good in countries where it takes longer or more words to say something than was the case in the original, but generally speaking, okay.

Most dubbed programmes use a local voice for each of the characters. For programmes featuring a large cast, the expense of matching one local actor to each on-screen actor can become significant. Hence, in a bid for economy, it is often the case that one actor is asked to take on the voice of several different characters. Generally speaking, if the actors are any good, the effect can again be reasonably transparent to the viewer. Asking an actor to take on multiple voices is a typical example of the 'trimming' trend – maintain the function with fewer components.

Meanwhile, swimming around at the bottom of the programming food-chain is the afternoon soap opera. A big problem with afternoon soaps is that while the cast of characters will tend to be large, the audience – and hence the revenue to the producers – will tend to be small. Make that an afternoon soap imported into a small country and the problem gets even worse. What to do in this situation?

The answer is not an easy one, but a clue coming from such a programme on Estonian television (ahem, we were watching purely for research purposes of course) is that using a single voice for the whole cast probably will not meet the definition of 'reasonably transparent'. Put three women in a scene at the hairdressers and give each of them the same very male voice and you have all the ingredients for a inducing a major psychological trauma into an audience that hasn't had due forewarning. Scary stuff, and very definitely the surrealist moment of our traveling month. The population of Tallinn, by the way, seemed unaffected.

Patent of the Month

A close-run thing this month in our search for the best patent. Our nearly-winner was US6,855,772 ‘Water repellant and Soil-Resistant Finish For Textiles’, mainly because of its connection to our oft-used self-cleaning clothes Ideal Final Result evolution case study.

The final choice, however, went to

United States Patent	**6,855,738**
Valette , et al.	**February 15, 2005**

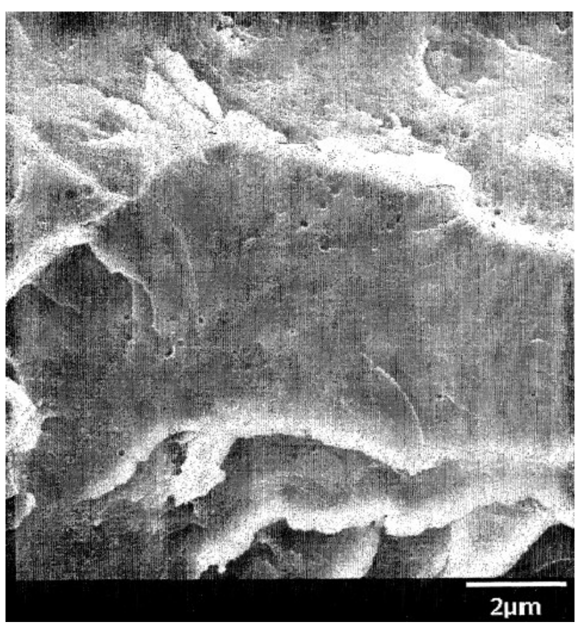
Nanoporous laminates

Abstract

A process of making a nanoporous substrate, such as the matrix in an electrical laminate, by grafting onto an organic resin backbone a thermolabile functionality by reacting hydrogen active groups of the organic resin with a compound containing thermolabile groups; then thermally degrading the thermolabile groups grafted on the organic resin to form a nanoporous laminate. Advantageously, the nanoporous electrical laminate has a low dielectric constant (Dk) because of the nanopores present in the laminate matrix.

Inventors: **Valette; Ludovic L.** (Haguenau, FR); **Marestin; Catherine** (Lyons, FR); **Mercier; Regis** (Irigny, FR)

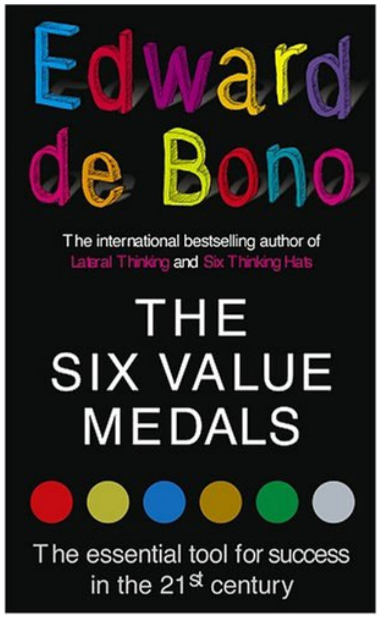
Assignee: **Dow Global Technologies Inc.** (Midland, MI)



The current trend of the electrical laminates industry requires materials with improved dielectric properties including lower dielectric constant (Dk) and loss factor (Df); superior thermal properties including high glass transition temperature (Tg) and decomposition temperature (Td); and good processability. Normally these attributes are in direct conflict with one another – improve one, and the likelihood is that the other ones will get worse. What the nanopores (Principle 31) achieve is a shift in the trade-off between the various parameters in the direction of the ideal final result system. The inventors claim that the nanoporous laminates of the invention have achieved an improvement of up to 20% in dielectric constant compared to an equivalent epoxy system without nanopores.

Best of the Month – Edward DeBono, The Six Value Medals

The Six Value Medals is Edward DeBono's 68th book. As probably suggested by the title, there is some common ground between this book and the earlier Six Thinking Hats and Six Action Shoes. The focus this time around, however, is the subject of 'value' and a thinking framework that causes readers to focus on six different types of value. Like Hats and Shoes, the book is easily readable in a couple of hours, and the ideas it contains are simple to grasp.



'Value' has always played a role in DeBono's business-focused work. In Six Value Medals he declares, "Almost any thinking and almost any action has an important value component. It is impossible to ignore values. Every decision we make involves values". Thus, while the emphasis continues to be on business, the book serves to transfer the idea of value to individuals and corporations alike.

The six Values identified in the book are:

- Gold – individual human values
- Silver – organizational values
- Steel – Quality values
- Glass – Creativity/Innovation/Change values
- Wood – Environmental values
- Brass – Perception values

The point of making the distinction between these different types of value is that frequently we ignore some or all of them when we are making decisions. By making each type explicit, the reader is presented with a simple checklist to be considered during any decision-making activity.

While it is not entirely clear that the names given to each of the six different values is either memorable enough or sufficiently 'obvious', there are some undoubtedly elegant and important ideas being expressed here. There is undoubtedly also a lot in common with the structure of both TRIZ and the (independent) work of Ken Wilbur. Wilbur, in fact, in his 'A Theory of Everything' book (see review in e-zine issue 29), has what is probably a more memorable model for 4 of the six value medals. In Wilbur's Theory, the world is divided into 'I' 'We', 'It' and 'Its' categories. The correlation between these and DeBono's definitions is almost uncanny – to the extent that you can almost imagine DeBono having Wilbur's book open next to him as he is writing:

Gold – I (internal, individual)
Silver – We (internal, collective)
Steel – It (external, individual)
Wood - Its (external, collective)

With the 'Glass' and 'Brass' values, however, DeBono then manages to identify a pair of serious shortcomings in Wilbur's model. Firstly, the 'glass' value highlights the static nature of the Wilbur model, and suggests that there are values to be considered relating to movement and change. How the 'I' views the 'It', or how the 'We' influences and impacts on the 'I' are both issues that the Glass Medal forces us to think about where Wilbur's model does not.

The 'brass' value, then, is about perceptions, and as such recognizes – as NLP has already done – that 'the map is not the territory' and that perceived values in any of the I/We/It/Its boxes are not the same as the actual values. Again this is an area that, although, Wilbur mentions it, is beyond the I/We/It/Its framework.

DeBono being DeBono means that one of his books is never going to describe a synthesis of anyone else's work. This, in the end, is the biggest flaw in the new book. As such, the reader is left with the distinct impression that a book with a few neat ideas in it could, by acknowledging the existence of a world of research beyond DeBono's island(s), have been transformed into something of real importance (*). This issue aside, the book is well worth a couple of hours of anyone's time. As usual, amidst the big ideas are several nuggets bound to provoke prolonged thought once the book has been filed on the shelf. Most notable of these for this author was:

"If you reward creative effort, you will get creative results. If you reward creative results you will not get creative effort."

A typical DeBono throwaway comment with a profound message attached to it.

(*) More on what happens when DeBono's idea of 'Glass' values get combined with ideas from Wilbur and NLP in a future article.

Investments – Transparent Transistors

Researchers at Oregon State University and Hewlett Packard have reported their first example of an entirely new class of materials which could be used to make transparent transistors that are inexpensive, stable, and environmentally benign. This could lead to new industries and a broad range of new consumer products, scientists say.

Photograph of a 1 inch by 1 inch glass substrate patterned with spin-coated zinc oxide transparent transistors, sitting on the top of a dollar bill. There are 56 transistors in the red box.

The possibilities include electronic devices produced so cheaply they could almost be one-time "throw away" products, better large-area electronics such as flat panel screens, or flexible electronics that could be folded up for ease of transport.

Findings about this new class of "thin-film" materials, which are called amorphous heavy-metal cation multicomponent oxides, were just published in a professional journal, Applied Physics Letters. The research was funded by the National Science Foundation and Army Research Office.

This is a significant breakthrough in the emerging field of transparent electronics, experts say. The new transistors are not only transparent, but they work extremely well and could have other advantages that will help them transcend carbon-based transistor materials, such as organics and polymers, that have been the focus of hundreds of millions of dollars of research around the world.

‘Compared to organic or polymer transistor materials, these new inorganic oxides have higher mobility, better chemical stability, ease of manufacture, and are physically more robust,’ said John Wager, a professor of electrical and computer engineering at OSU.

‘Oxide-based transistors in many respects are already further along than organics or polymers are after many years of research, and this may blow some of them right out of the water."

‘Frankly, until now no one ever believed we could get this type of electronic performance out of transparent oxide transistors processed at low temperatures,’ Wager said. ‘They may be so effective that there will be many uses which don't even require transparency, they are just a better type of transistor, cheap and easy to produce.’

The newest devices are zinc-tin-oxide thin film transistors, according to collaborating researchers in the OSU College of Engineering, OSU College of Science and at Hewlett Packard.

They are an evolution of zinc oxide transistors, which gained attention as the world's first see-through transistor when OSU scientists announced their discovery last year.

But this new material combines the characteristics of different elements to give levels of electronic performance and 'mobility' – in electronics, an observation about how fast electrons can move within a material – that are an order of magnitude faster than the earlier transparent transistors, Wager said.

They are amorphous, meaning they have no long-range crystalline order, which helps to keep processing costs a great deal lower. They are also physically robust – hard to scratch, chemically stable, resist etching, and have a very smooth surface.

They are made from low cost, readily available elements such as zinc and tin, which raise no environmental concerns.

'What has been most surprising, however, is that we can make high quality oxide transistors with these new materials at just above room temperature,' Wager said. 'Simply put, that's shocking. Most integrated circuits made today, by comparison, are produced at temperatures between 700-1,100 degrees centigrade.'

According to the OSU and HP researchers, this group of transistor materials will not challenge the silicon-based products that form the basis for most of the computer industry. But they may find their way into specialty electronic products – many of which do not yet exist – that will probably lead to billion-dollar industries of the future.

'HP is excited about the possibilities that this development may enable, especially for our customers in imaging and printing,' said Tim Weber, the director of the Advanced Materials and Processes Laboratory located in Corvallis, Ore. 'We are pleased with the rapid progress the OSU and HP team has made in this area.'

OSU has used a multidisciplinary research approach to the creation of these new transparent transistors, purposefully focusing on materials that have desirable physical properties, and could be cheaply and realistically produced for the consumer marketplace.

The group of 'heavy metals' that could potentially yield new advances also includes such elements as gold, silver, mercury, arsenic or lead, but these elements have been intentionally avoided because of their real-world cost or toxic environmental concerns.

Further fundamental research will continue on such topics as device physics and modeling, transparent circuits, new materials and other areas.

Private industry is already beginning to identify new applications for these materials, Wager said.

One possibility is with gas sensor systems. These sensors are used extensively in automotive and other mechanical applications, and the new zinc-tin oxide transistors might allow the creation of a new type of gas sensor whose sensitivity is electronically controlled over a wide dynamic range.

In the field of transparent applications, there should be uses in consumer electronics, transportation, business and the military.

Automobile windshields could transmit visual information. Glass in almost any setting could also double as an electronic device, possibly improving security systems or transparent displays.

The military is extremely interested in research of this type because of possible uses in sophisticated technology or fighting equipment. Liquid crystal displays could be improved. New types of copy machines may be created. Better solar cells are possible.

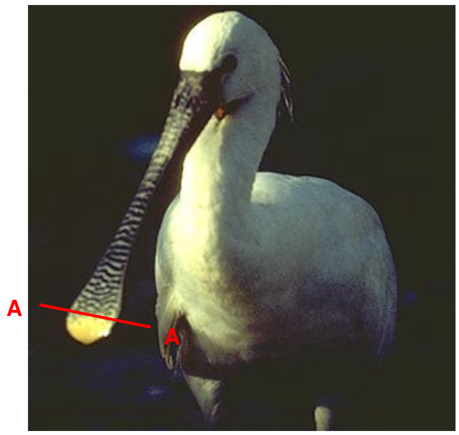
‘One other thing that comes to mind is games and toys,’ Wager said. ‘It's not unusual for the creators of innovative game products to be the first people to implement a new technology. Some of the first illustrations we've seen of the things you could do with transparent electronics have been in science fiction movies that show futuristic types of computer equipment.’

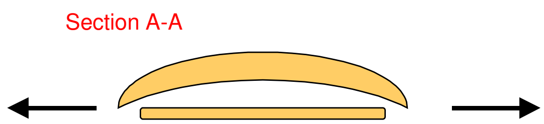
‘Some of those things, which were basically special effects produced by Hollywood, may soon become a reality,’ he said.

Biology – Spoonbill

Many species of bird feed in the shallow waters on the edge of rivers and ponds. When the water is clear, prey can be located visually, but when it is not, feeding can become a problem.

The spoonbill spends a lot of its time in shallow water feeding and has developed a number of features that help to solve the muddy-water problem. Firstly, it sweeps its open bill from side to side in the water to sift up food like small fish, shrimp, mollusks, snails and insects. The cross-sectional shape of the bill has evolved such that the side-to-side motion creates a vortex pattern that is very effective at lifting prey up from the bed. As may be seen from the figure below, the upper and lower portions of the bill together form a very effective lifting surface.





Then, after successfully stirring up its prey, the spoonbill has touch receptors in its bill that help them feel their prey.