House, released on 19 September 2000. The release states that Lane called upon 'the scientific community to voice the importance of international collaboration in S&T'. It further notes that 'one determinant of the US success in the knowledge-based economy will be how well the US manages its S&T partnerships with countries like India in order to mutually benefit from each other's strengths'. Ramamurthy underlined 'the importance of the roundtable as a mechanism for transforming the current donor–recipient model prevalent in S&T to one of mutual partnership and cooperation'.

On the occasion of the second Indo-US High Level Roundtable on S&T a Roundtable Joint Communiqué was presented by Lane and Ramamurthy to the Indian Prime Minister. The joint statement listed collaborations in S&T in five areas, namely genomics, agricultural biotechnology, nanoscale science and engineering, computer modelling, mainly weather prediction and energy. In genomics, both sides agreed that 'they were poised for greater co-operation and accomplishment in the global fight against diseases; especially joint activities that would contribute to understanding how genetic polymorphism and gene expression influence susceptibility or resistance to infectious or chronic diseases'. For agricultural biotechnology, attention was brought to the role which 'biotechnology can play in ensuring food safety and environmental protection'. As part of the programme on nanoscale science, areas of joint collaborations would be advanced optical, electronic, magnetic and micro-mechanical devices, and also nanobiostructures and nanobiotechnology. Possible co-operation in setting up two centres of excellence, one for modelling and visualization and the other in engineering design analysis was considered. The formation of a 'worldwide digital library' was also envisaged. Energy development, both sides felt must be 'without environmental degradation'. The 'Jai Vigyan' mission and the Indian Millennium Mission 2020 by the Government of India, for integrated rural and small town development with 'physical and electronic connectivity', as well as energy-related areas of biomass utilization, etc. was discussed.

The Forum will comprise seven members from each side. While seven members from the Indian side now constitute the Governing Body of the Forum, as yet only six from the US have been identified (Table 1).

Finally, both sides agreed to hold roundtables on a regular basis. It was further decided to hold the first Governing Body meeting concurrent with an Indo-US workshop in two of the five identified areas to begin with, genomics and nanostructures, towards the end of the year, in India.

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RESEARCH NEWS

The future of flat panel displays

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The technology of electronic displays used in the area of televisions, personal computer screens and the like has been galloping at an amazing pace. The visual image obtained by conversion of electronic signals on the electronic display screen, aids information transfer between man and machine. Individual picture elements called pixels create a pattern by an 'on and off mechanism', including play in brightness and contrast. The pixel array visually enables the data transfer in the form of pictures, symbols or graphs.

Today's display screens are primarily based on old vacuum tube technology, first conceptualized in the mid nineteenth century. The technology has a basketful of woes that include manufacturing expenses, a fragile product and possible risk to human safety. What hide behind the screen are high voltages, as electrons are accelerated at large potentials to illuminate the screen. Large screens, with dimensions of about 10 feet by 8 feet with the desired resolution are yet out of reach technically.

How distant is research from achieving a cost-effective product, a screen both cheaper and safer to use, circumventing the cathode-ray tube technology? Existing flat panel displays are basically motivated from an idea to hang a television receiver on the wall, as would a painting. These displays are designed both on emissive and non-emissive phenomena. Emissive displays have gas discharge, plasma panel and electroluminescence as examples and non-emissive displays include liquid crystalline, electrochromatic and electroactive solid types. In a consumer-driven environment, the costs do still remain high and out of bounds. There are other problems as well. As any laptop owner would vouch for, the user finds it difficult to view his screen from any angle with zero distortion of the image. Liquid crystal displays (LCD) are ridden with slowness, in addition to poor visibility of the monitors as a commonly experienced problem.

So, where is the solution? The solution is to have a quantum change in technology. The next generation of display screens would be flat and could-you-believe-it, cheap too. Liquid crystal technology meets the need in a limited way in terms of cost and power requirement. Desktop personal computers still remain the exclusivity of cathode-ray tube design. Flat panel displays on the shelf are expensive.

The traditional display screens are generally made up of a luminescent material such as zinc sulphide (ZnS). ZnS has an inherent problem. A screen coated with this material requires electrons of about 25 keV energy to illuminate and brighten up the screen. Nanoparticles with large quantum efficiencies have already been reported in published literature[1]. The new ZnS coated screen, made up of ZnS nanoparticles, would require electrons of less energy, of the order of a few hundred eV, to illuminate the display. The subsequent phase of technological development requires low energy electrons shooting at these new ZnS nanoparticle screens.

The changeover from the equivalent of an electron gun in a vacuum tube is also necessary. Aggarwal *et al.*[2] have recently demonstrated enhanced photoelectron emission from a palladium (Pd) metal film, good enough for use in field emission applications. The electron emitter, an entire panel similar to the display screen, needs to have minute needle-like emitters acting as a concerted array of individual emitters for brightening the screen. Oxidation of the metal thin film causes self-assembled array of oxide 'tip' structures. The experiment done was with Pd metal films (40 to 200 nm) deposited by pulsed laser ablation at room temperature, in vacuum (10^{-6} torr), on oxide substrates such as MgO and $LaAlO_3$ and subsequently annealed in oxygen at temperatures between 600 and 900°C. The films were characterized using X-ray diffraction (XRD), atomic force microscopy (AFM) and photoelectron emission microscopy (PEEM).

Interestingly as seen by AFM, an uniform array of surface features (tips) of approximately 1 µm height and a uniform spacing of about 2 µm are obtained. These uniform tip arrays on the surface could be controlled (height of the tips and spacing between them) based on experimental parameters such as film thickness, annealing temperature and oxidation conditions. This work is novel in the field emission display technology due to ease in processing. Yet, drawbacks remain even for this design as it continues to use strong electric fields to eject electrons from the needle-like tips. Safety becomes an issue due to the expected demand for high voltage circuitry. In addition, repeatability and uniformity of needle shape, height and spacing are constraints for viability in manufacture. Non-uniformity would mean that only the sharpest tips would emit electrons on application of the electric field.

Whither from here? The search for a low energy electron emitter panel, which is both easy to construct and which throws uniform flux of electrons has just been proposed. Research has come up with a practical solution for electron emission from a planar cathode[3]. A new method, based on reducing field strengths, to remove an electron from a metal surface by a factor of ten, has just been proposed. The planar cathode is designed by depositing a 5 nm thick (ultra thin) layer of semiconducting material (UTSC) on a metal such as platinum (Pt). The planar cathode can be in planar or curved geometry (Figure 1). The metal (Pt) and semiconductor layers (TiO_2) are deposited using conventional vacuum techniques on a plane surface of a Si wafer (Figure 1 top). Nano-protrusions of TiO_2 are constructed by high energy bombardment of a rutile crystal using 30–40 MeV C_{60} cluster ions (Figure 1 bottom).

The basic concept behind removing electrons from a solid surface into the vacuum lies with the electrons having enough energy to surmount the potential barrier present (as in photoemission and thermionic emission) or the width of the barrier is reduced with an electric field, allowing electrons to escape (field emission). Field emission at room temperature is possible by the new method of emission, by a serial process from solid-state field controlled emitters. A schematic description of a solid-state field controlled emitter (SSE) is shown in Figure 2. A serial process uses a solid state Schottky metal–semiconductor barrier to inject electrons into a negative electron affinity (NEA) surface. The NEA surface has no appreciable concentration of electrons in the conduction band. So an injection of electrons into the NEA surface becomes essential, which is the first step in the two-step serial process. In this case, the NEA surface is the UTSC that is layered onto a Pt surface. The metal layer acts as a reservoir for electrons. The second step is the electron emission from a localized area at the n-type semiconductor surface. The localized NEA surface area is induced by an applied field. Tuning of the semiconductor ensures the creation of a metal semiconductor Schottky junction having a barrier height in the range of 0.1 eV. This will enable enough flux of electrons at room temperature for injection into the UTSC layer. The successful experimental results are supported by a qualitative model put forward by the same group[4] to explain the mechanism by which the barrier height is reduced, facilitating jumping of the electrons out of the metal layer.

The research on this novel solid-state field controlled emitter is being patented with a commercial product to be made available within the next two years. With the electron emitter in place, a new dawn is expected to be ushered in for flat panel displays.

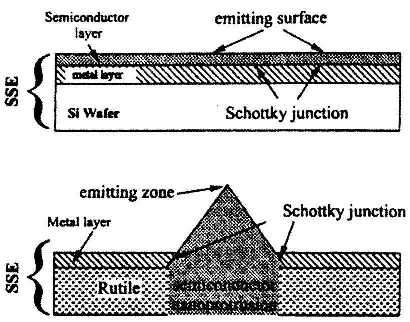

Figure 1. Planar cathode geometries for solid state emitters. (Top) thin film geometry; (Bottom) nano-protrusion geometry (from ref. 3).

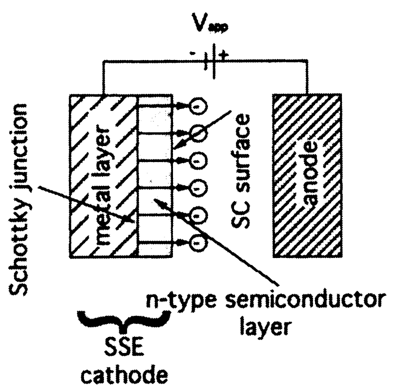

Figure 2. Schematic description of a solid-state field controlled emitter (from ref. 3).

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