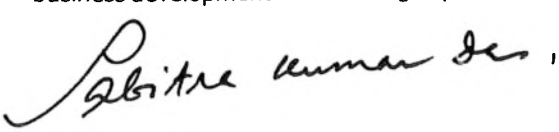
## Nano materials & their welding

Exciting developments are taking place in the field of Nano materials & their joining techniques. Nanotechnology, as we all know, involves working with materials at the nanometer level, that is tens of atoms, to create structures, devices and systems that have useful and unique new properties. Many material properties change dramatically when they are very small (when their surface area gets very large compared to their volume). This can change optical, electrical and magnetic properties, to name a few. For instance, opaque substances become transparent (copper); inert materials become catalysts (platinum), stable materials turn combustible (aluminum); solids turn into liquids at room temperature (gold); insulators become conductors (silicon).

Nanomaterials can be produced by reducing the size of materials to a nano-scale (top-down approach) or building up structures from the atomic level (bottom-up approach). Nanotechnology becomes possible because materials can now be manipulated on the nano-scale (such as by electron beam lithography) and can now also be viewed and measured on this scale (atomic force microscopy, electron microscopy).

Scientists have developed many ways to make individual nano-objects, but not many ways to securely join them together. Most everyday joining techniques cannot be applied at the nanoscale, as nano-objects are easily destroyed by heat. But now we have reached a point where the ability to weld individual nanoscale objects such as nanowires and nanoparticles together is becoming vitally important for nanotechnology applications such as nanosensors and nanoelectronics. Researchers have now demonstrated the ability to reliably weld individual nano wires and nano objects into complex geometries with controllable junctions using tiny blobs of metal solder less than 250 atoms across. This represents a significant breakthrough for the current and future bottom-up localized assembly, integration, and repair of micro- and nanodevices. This nanoscale electrical welding technique radically improves the spatial resolution, flexibility, and controllability of welds between individual nanowires and nanoobjects. The key advance is avoiding detrimental current flow though the nanoobjects to be joined and instead to locally deposit nanoscale volumes of a chosen metal at the weld site by Joule heating a sacrificial nanowire. The nanosolder is deposited by heating a tiny metal wire in contact with the materials to be joined. The solder wire melts and flows onto the join. The welding can be watched in real-time inside an electron microscope, allowing the choice of exactly where, and how much, nanosolder is deposited. The use of nanosolder is particularly exciting because the strength and conductivity of the join can be engineered at the nanoscale by controlling the chemistry, structure, and volume of solder material used. Some researchers have also demonstrated that dissimilar nanowires can be welded together, using a third material as solder. They specifically chose gold-tin alloy solder widely used in macroscopic welding due to its excellent conductivity, low melting point, and large corrosion resistance to result in an ultra low electrical resistance joint between nanowires. The new nanowelding technique can be used to join nano-objects with a wide range of shapes and chemistries, and so could be used in the future as part of a 3D nanoscale fabrication line. Nanosolder can also rejoin things that have come apart during use, such as interconnect wires in computer chips which often fail by the formation of holes (by 'electromigration').

Nanotechnology has already had significant impacts, with materials engineering and can play a very important role in industries like electronic, optoelectronic, biomedical, pharmaceutical, cosmetic, transport, membrane, catalysis and energy sectors. Within these industries, materials scientists and engineers will fulfill a range of roles, from researcher to process engineer to quality control to business development to marketing to patent law.



**P. K. DAS**
Editor
E-mail : iwjedit@rediffmail.com