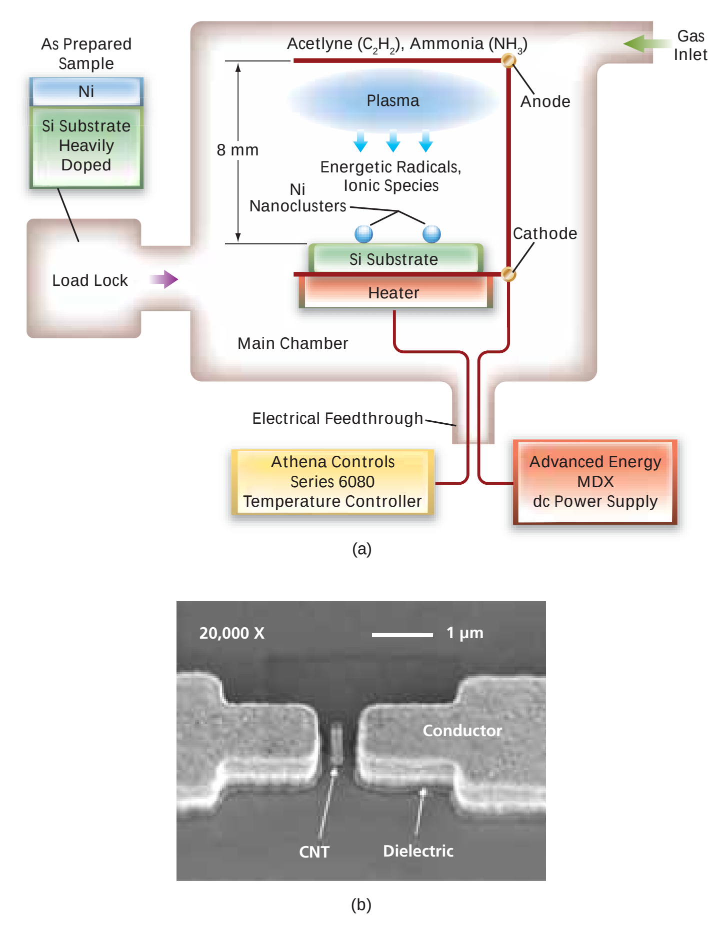

(a) In the **dc PECVD Growth Chamber**, the sample was placed on a 3-in. (7.6-cm) Mo ring, where the wafer was transported from the load lock to the main chamber. (b) A single, vertically aligned tube is seen centered precisely within deep trenches, which was formed using high throughput processes.

themselves to the integration of PECVD-grown tubes for applications ranging from interconnects, nanoelectromechanical systems (NEMS), sensors, bioprobes, or other 3D electronic devices.

Chemically amplified polyhydroxystyrene-resin-based deep UV resists were used in conjunction with excimer laser-based (λ = 248 nm) step-and-repeat lithography to form Ni catalyst dots ≈300 nm in diameter that nucleated single, vertically aligned tubes with high yield using dc PECVD growth. This is the first time such chemically amplified resists have been used, resulting in the nucleation of single, vertically aligned tubes.

In addition, novel 3D nanoscale architectures have been created using top-down techniques that integrate single, vertically aligned tubes. These were enabled by implementing techniques that use deep-UV chemically amplified resists for small-feature-size resolution; optical lithography units that allow unprecedented control over layer-to-layer registration; and ICP (inductively coupled plasma) etching techniques that result in near-vertical, high-aspect-ratio, 3D nanoscale architectures, in conjunction with the use of materials that are structurally and chemically compatible with the high-temperature synthesis of the PECVD-grown tubes. The techniques offer a wafer-scale process solution for integrating single PECVD-grown nanotubes into novel architectures that should accelerate their integration in 3D electronics in general.

NASA can directly benefit from this technology for its extreme-environment planetary missions. Current Si transistors are inherently more susceptible to high radiation, and do not tolerate extremes in temperature. These novel 3D nanoscale architectures can form the basis for NEMS switches that are inherently less susceptible to radiation or to thermal extremes.

This work was done by Anupama B. Kaul, Krikor G. Megerian, Paul A. Von Allmen, and Richard L. Baron of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to:

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Process To Create High-Fidelity Lunar Dust Simulants

Marshall Space Flight Center, Alabama

A method was developed to create high-fidelity lunar dust simulants that better match the unique properties of lunar dust than the existing simulants. The new dust simulant is designed to more closely approximate the size, morphology, composition, and other important properties of lunar dust (including the presence of nanophase iron).

A two-step process is required to create this dust simulant. The first step is to prepare a feedstock material that contains a high percentage of agglutinate-like particles with iron globules (including nanophase iron). The raw material selected must have the proper mineralogical composition. In the second processing step, the feedstock material from the first step is jet-milled to reduce the particle size to a range consistent with lunar dust.

This work was done by Robert Gustafson of Orbital Technologies Corp. for Marshall Space Flight Center. For more information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-32729-1.