NEWS from ARO-FE (July 2001) : *Toyota Technological Institute (TTI) develops a* **Scanning** *Time-of-Flight (TOF)-type* **Electron-Stimulated Desorption (ESD) Ion Microscope** ***(SESDIM)*** *to measure two-dimensional* ***hydrogen*** *distribution on solid surfaces.*

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"Respect the Spirit of Research and Creativity and Always Strive to Stay Ahead of the Times" ***Sakichi Toyoda.*** *Sakichi Toyoda, one of Japan's best-known inventors, spent all of his life contributing to society through his many inventions. It was this creative drive which brought Toyoda into the automotive industry. The Toyota Technological Institute (TTI) adopted Toyoda's spirit from its inception. It has applied this spirit in both education and research as its founding philosophy. To meet the social needs, TTI has established two areas of specialization whose future development is most promising:* ***Information Aided Technology*** *and* ***Future Industry-oriented Basic Research****. TTI's professors are first-class, world known scientists with a fixed five-year term. The renewal process is based on their performance in research and teaching.* ***Information Aided Technology*** *covers Information-Driven Dynamic Systems; Thermofluid Engineering; Integrated, Intelligent Design; Integrated Manufacturing Engineering; Ultra-micro Processing; Image Sensing and Processing Systems.* ***Future Industry-oriented Basic Research*** *covers innovative, Nano-Controlled Ultimate Data Storage Materials; Molecular Design and Structure Control for Functional Polymeric Materials; Noble Crystals and Semiconductors; Structure-Controlled Materials;* ***Surface Physics****; Inorganic Materials with Controlled Texture.*

The TTI Surface Science laboratory has developed a two-dimensional hydrogen analyzer on solid surface using the Time Of Flight - Electron Stimulated Desorption Spectroscopy (TOF-ESD) method combined with a pencil-type electron gun originally designed for use in the Scanning Electron Microscopy (SEM). **Hydrogen on solid surfaces is an issue of great interest in chemistry, physics and device technology.** Also, the detection of hydrogen on solid surfaces is difficult or impossible by conventional analytical methods. ARO-FE has met and established excellent rapport with SESDIM's inventor (Dr. Kazuyuki Ueda, Fig. 1) and is ready to facilitate any technical interactions between TTI and DOD technical organizations on this or other topics of interest.

Figure 1 shows a schematic drawing of the SESDIM. The TOF-type mass analyzer is constructed from a three-grid mesh, microchannel plates (MCPs) with effective diameter of 70mm and a fluorescent screen. The pencil-type electron gun was developed by TTI, with JEOL (Japan Electron Optics Lab. LTD). This is operated in an ultra high vacuum (UHV) chamber through computer controlled SEM electronics. The Thermal Field Emitter (TFE) provides a fine-focused electron beam in the low-electron-energy range (e.g., 300nm in diameter at 800eV). An electron beam with this energy range is easily pulsed by a high-speed pulse generator with duration of 220ns. Each signal of electron-stimulated desorbed ions is detected by the MCPs; it is then counted and stored in the memory of a personal computer. Accumulation of the signals for 10,000 pulsed electron beams makes a fine TOF spectrum. The yield of desorbed ions is defined by integration of the peak in the TOF spectrum. In order to obtain the image of hydrogen distribution on solid surfaces, the electron beam is scanned digitally over the sample surface and the yield of each beam position forms a pixel of the image on the gray scale.

Figure 2 shows a hydrogen-terminated silicon surface. This surface was used as a resist for non-masked patterning by a focused electron beam. The letters (TOYOTA) were patterned by the continuous electron beam prior to the two-dimensional hydrogen analysis by a pulsed electron beam. The written letters appear clearly in the hydrogen image as shown in the figure.

Figure 3 (a) and (b) show an oblique sharp line (marked by arrows) which expresses the contrast of H^+ signals from a deeply scratched line during mechanical grinding. Since the scratch revealed a new Si surface on both Si and SiO_2 lines, the brighter contrast appears to be similar to the Si lines. In a similar manner, the O^+ signal intensity expresses a darker contrast as shown in Figs 3 **(c)** and **(d).** Fig 3 **(e)** represent a series of TOF-ESD spectra from Si and SiO_2 lines.

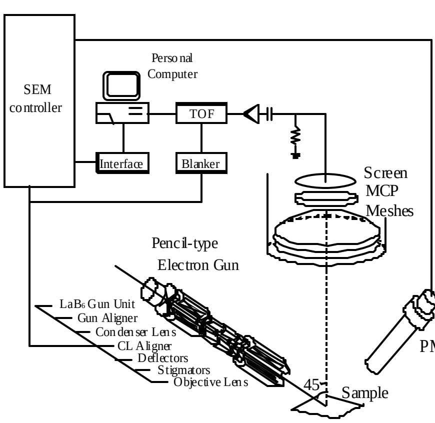

Figure 1

Figure 2

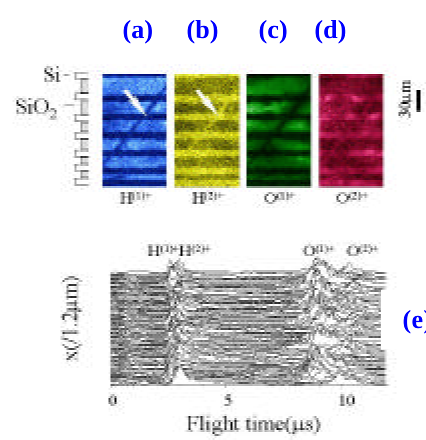

Figure 3