NEWS from ARO-FE (July 2002):

Near-field & nonlinear nano-photonics

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Applications of Nano-photonics technology are growing rapidly in the fields of optical observation, analysis, manipulation and fabrication of nanostructures. Recently, Prof. Satoshi Kawata and Prof. Yasushi Inouye of the Graduate Schools of Information Sciences and Frontier Biosciences of Osaka University have provided interesting examples in the field of near field Raman spectroscopy. When a sharpened metallic tip is placed in the focused spot (Fig. 1(d)), localized surface plasmon polaritons are generated. The plasmon polaritons increase the intensity of the electric field, just under the metal tip, and generate images with high spatial resolution. For instance, a spatial resolution of 30 nm has been achieved in nano-spectroscopy and nano-imaging. Figure 2 shows an example of nano-imaging of Si grating where the image using a metallic tip probe gives a better in depth structure than the one produced by an STM. In nonlinear optics field they show nano photo-fabrications at 100 nm spatial resolutions using a Ti:Sa laser for inducing the nonlinear photo-polymerization. Figure 3 shows a fabrication process of a micro bull. Polymerization occurs only at the focused spot of the near-infrared laser where the two-photon absorption occurs. The focus spot is moved three dimensionally by galvano-mirrors as shown in Fig.3 (a). CAD data is used to create the surface of the bull depicted in Figure 3 (b). Figure 3 (c) shows the bull (whose inside is not yet polymerized) created by washing away the monomer. The final stage, shown in Figure 3 (d), is obtained by polymerization via ultraviolet light radiation. The bull's dimensions are 8 μm in length and 5 μm in height as shown in Fig.4. Another example of nonlinear optics is the generation of three-dimensional imaging of molecules by using the CARS (Coherent Anti-Stokes Raman Scattering) phenomenon produced with Ti:Sa lasers.

Figure 1: Schematic diagrams of near-field microscopes: (a) Micro aperture probe; (b) Micro aperture fiber probe; (c) Micro sphere aperture-less probe; (d) Metallic tip aperture-less probe

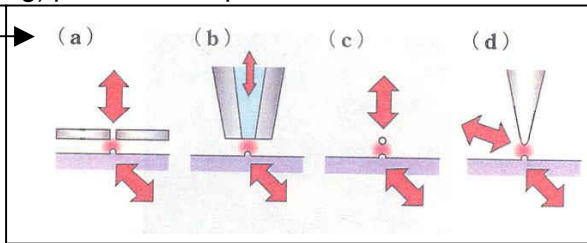
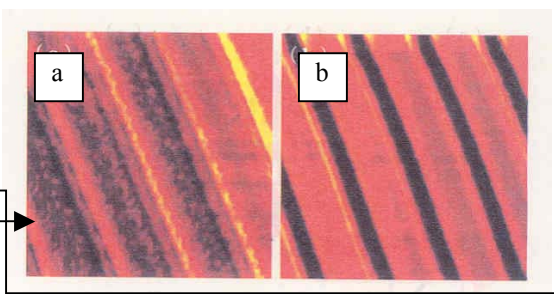


Figure 2:

Nano-image of silicon grating with period of 240nm

(a) Image obtained with metallic tip aperture-less probe

(b) Image obtained with conventional STM (Scanning Tunneling Microscope)



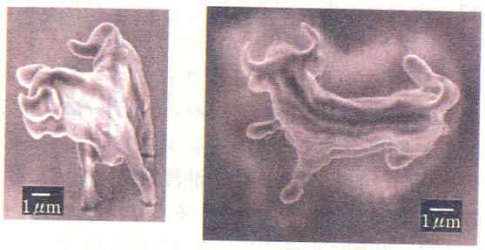


Figure 4: Micro bull fabricated by process described in Fig 3. Its dimensions are 8 μm in length and 5 μm in height

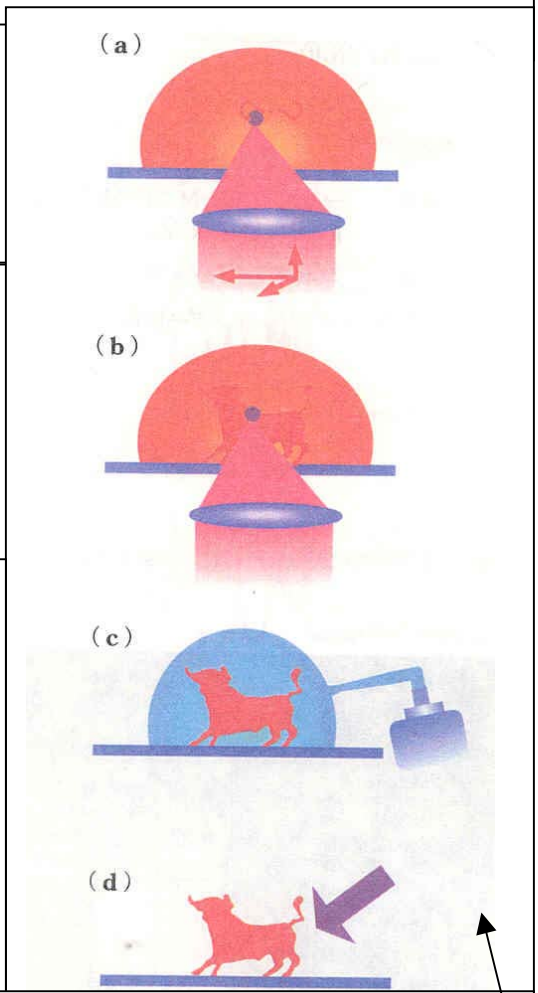


Figure 3: Fabrication process of the micro bull. (a) (b) Nonlinear photo-polymerization process (only surface); (c) Removing monomer process (d) Inside photo-polymerization process