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## **NANO PLASTIC FORMING FOR DEVELOPMENT OF FUNCTIONAL SURFACES**

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### **ABSTRACT**

Surface functions of materials depend on not only chemical components of surface material but also nano/micro surface structure. Many researchers challenged to develop new surface functions by fabricating nano/micro structures, which we call the Functional Surface. Nano plastic forming was developed to achieve high through-put and low cost nano/micro machining for development of functional surfaces. Among many examples of functional surfaces developed by the nano plastic forming technique, detail of the metal nano dot array is discussed. A nano dot array exhibits unique optical characteristics, and is expected for application to biosensors.

**Keywords:** nano micro manufacturing, metal forming, surface functions, nano dot array, plasmon sensor.

### **INTRODUCTION**

Surface properties of materials depend on not only chemical components of surface material but also nano/micro surface structure. Many examples are found in nature such as butterfly wings and lotus leaves. Inspired from these examples, many researchers were challenged to develop new surface functions by fabricating nano/micro structures, which we call the Functional Surface (Yoshino, 2006). Wettability control surface and reflection control surface are good examples of functional surfaces (Wenzel, 1936, Cassie and Baxter, 1944). These surface functions can be modified by fabricating an array of small protrusions on a material surface. In order to fabricate these small surface structures, many researchers usually utilize the UV/EB lithography and wet etching processes. However, these methods are not always suitable for fabrication of functional surfaces because of its restriction on work materials, complexity of process and high facility cost. The authors proposed a new nano manufacturing method named the nano plastic forming to address the abovementioned problems (Yoshino, 2004). Detail of nano plastic forming technique and some examples of functional surfaces developed by nano plastic forming is introduce.

### **NANO PLASTIC FORMING AND FUNCTIONAL SURFACES**

Fig.1 shows (a) a nano plastic forming (hereafter NPF) tester and (b,c) specially designed diamond tools developed for experiments. It has computer controlled precision X-Y stages and a Z stage. A specimen is mounted on the XY stage, and a diamond tool is mounted on the Z stage. By repeating indentation of the diamond tool on the specimen, various nano/micro surface structures can be fabricated. The complete process of imprinting involving the movement of stages and indentation load is controlled by a computer. Figure 2 shows some

examples of surface textures fabricated by using NPF technique. (a) is nano dimple array on a quartz slide glass, and (b) is nano groove grid on a PMMA plate. (c) is metal (Au) nano dot array fabricated by a combination of NPF and self-organization by annealing. It is confirmed that surface structures smaller than  $1\mu\text{m}$  can be manufactured by simple process based on metal forming technique.

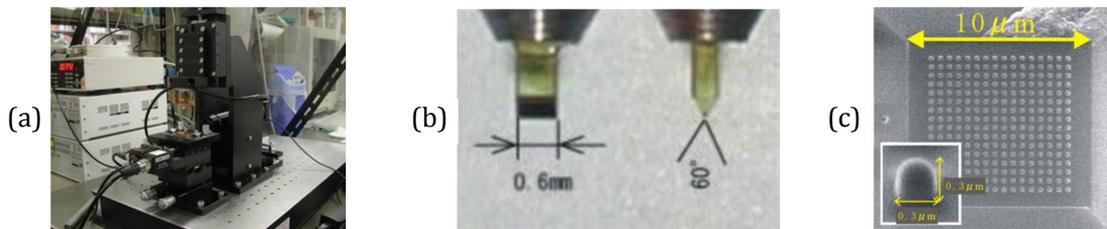


Fig. 1 - Nano plastic forming tester and specially designed diamond

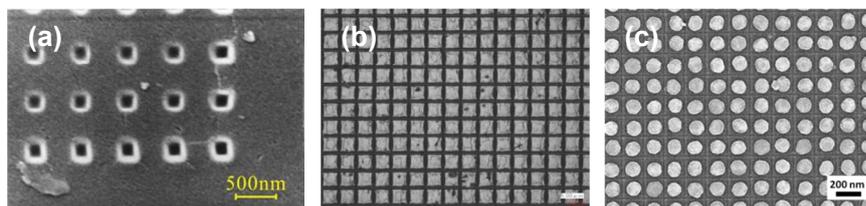


Fig. 2 - Nano plastic forming tester and specially designed diamond

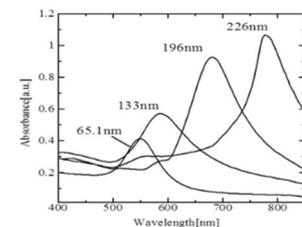


Fig. 3 - absorption spectrum of nano dot

An Au nano dot array occurs in the localized surface plasmon resonance (hereafter LSPR) with the incident light. LSPR is collective oscillation of free electrons in the metal dots due to the electric field vibration of the incident light. The incident light whose wavelength is matching with the resonance frequency is absorbed by the metal dots due to the localized surface plasmon resonance, and a peak appears on the absorption spectrum as shown in fig.3. Since peak wavelength is affected by the medium around the dot, such as adhered biomolecules, those biomolecules can be detected by measuring the shift of the peak wavelength. Because this detection method is much simpler than the conventional method, applications of nano dot array to sensors are expected.

## ACKNOWLEDGMENTS

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