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Fabrication of A Chemical Thermal Probe

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Most SPM sensors utilize a current-imaging technique or force-imaging techniques that allow imaging a nanoscale topography of the surface. For high sensitivity, the cantilever stylus should have a very sharp tip and a low force constant, and a high mechanical frequency. In this work, thermal imaging technique using bimetallic Si_3N_4 micro-cantilevers is investigated. The temperature change and heat flow across the fabricated bimetallic cantilever will create angular bending of the bimetallic lever. Its thermal response was qualitatively examined during an endothermic reaction of the chemicals using optical deflection methods. The chemicals used in this experiment is tetradecanol- $CH_3(CH_2)_{13}OH$ and with a known phase transition temperature is ~313K.

A roughly 100nm Al/ 20nm Pt thin film layer was deposited on the backside of the Si_3N_4 cantilever using thermal evaporator for thermal probe application. The dimensions of the rectangular Si_3N_4 cantilever are ~10 μm wide, ~100 μm long and ~0.4μm thick. The bimetallic cantilever with a supporting beam was attached to a stainless steel block. This block was wrapped with a nickrome wire in order to raise the temperature of the bimetallic cantilever. During heating procedure, the temperature was measured using a thermocouple which was attached to the stainless steel block. The tetradecanol $CH_3(CH_2)_{13}OH$ was placed on the cantilever supporting beam after measuring the hysteresis curve of the cantilever upon heating and cooling. The lever deflection was measured using a position sensitive detector. The laser diode with 670nm wavelength and maximum output power 3 mwatt has been utilized for measurements of the cantilever deflection. The bimetallic cantilever was heated upto 318K and cooled down slowly. It took about 10 minutes to raise the temperature of the cantilever from room temperature(~300K) upto 318K. The tetradecanol $CH_3(CH_2)_{13}OH$ is known to have endothermic reaction at 313K. It changes its solid phase and become liquid phase at 313K. Therefore, the heated bimetallic cantilevers will be expected to lose its thermal energy during phase transition of solid phase $CH_3(CH_2)_{13}OH$ into liquid phase. The required amount of the heat is found to be 225.76cal/gram using our caloriemeter meaurements.

The relative intensity of the cantilever deflection abruptly decreased from relative intensity of 40 at cantilever temperature of ~313K to 18 at 315K, due to the heat loss of the cantilever to the chemical substance tetradecanol. This observed phenomenon coincides with phase transition temperature 313K of tetradecanol. These experiments present bimetallic scanning probe microscopy as an excellent candidate for chemical sensor in an atmospheric environment. Depending upon the chemical reaction, whether it is exothermic or endo-thermic, the specific microscale cantilever stylus sensor can be fabricated and currently under our investigation.

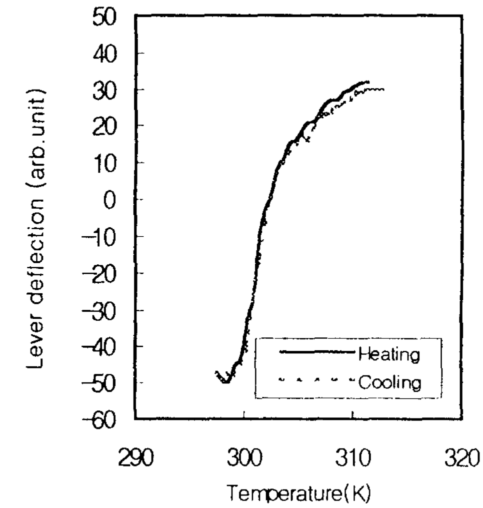

Fig.1.

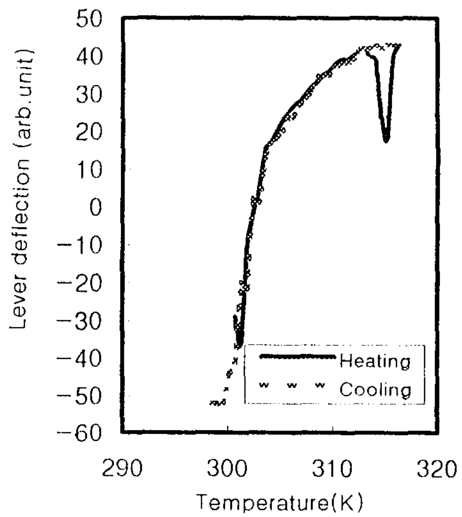

Fig.2.

Fig.1 The relative intensity for the bimetallic cantilever deflection versus temperature.

Fig.2 The relative intensity for the cantilever deflection versus temperature with chemical tetradecanol on the cantilever.