레이저 직접 박막 패터닝 및 응용
Direct Laser Patterning of Thin Films and Its Application

신현권, 이형재, 유형근, 심보연, 이명규
연세대학교 신소재공학부

myeong@yonsei.ac.kr

Modern electronic devices commonly require metal thin film patterns that are used for electrodes, metallization lines or interconnect. These patterns are typically fabricated by the photolithographic technique combined with vapor deposition. Although photolithography can provide high-resolution patterns, it also requires high-cost facilities and a number of process steps including photoresist deposition, developing, and etching. The increasing demand for low-cost, low-temperature, and large-area fabrication has led to a fervent search for alternatives [1-4].

In this paper, we show that silver thin films solution-deposited on transparent substrates can be patterned by direct exposure to a pulsed Nd-YAG laser beam incident from the backside of the substrate (wavelength = 1064 nm, pulse width = 6 ns, repetition rate = 10 Hz, maximum average power = 8.5 W). Thin films were deposited on glass and plastic substrates using a commercial Ag nanoparticle solution (particle size = 25 ± 10 nm) and then annealed at temperatures below 450 ^oC in ambient atmosphere. This method involves the light-matter interaction where a laser pulse impinging on the film-substrate interface generates a thermo-elastic force into the film and a moderate cohesion of the nanostructured film enables the localized desorption of material upon irradiation by a spatially-modulated laser beam, giving a good fidelity of pattern transfer. Sharp-edged patterns with feature sizes scaled down to 2 μm could be fabricated over several square centimeters by a single pulse with a pulse energy as low as 850 mJ. Combined with the absence of photoresist and vacuum processes, this method provides a simple high-resolution scheme for patterning metal thin films over large areas at low temperatures.

We also demonstrate that the desorbed film can be transferred into the receiver substrate made in contact with the original film, thus giving a printed pattern. In this process, the receiver substrate is not exposed to the laser beam. This made it possible to print patterns on a variety of substrates (Si, glass, and plastic) without damage. The printed patterns, in the as-deposited film state, could be made mechanically stable and highly conductive after annealing at temperatures higher than 150 ^oC. Organic pentacene thin film transistors have been fabricated on SiO_2/Si substrates using the printed source and drain Ag electrodes (channel length = 17 μm. width = 340 μm). The room temperature mobilities were

measured to be 10^{-1} ~ 10^{-2} $cm^2V^{-1}s^{-1}$, which are typical values for pentacene [5]. This parallel laser printing provides an effective new method for fabricating metal thin film patterns on solid substrates.
We found that this direct laser patterning scheme is applicable not only to the solution-deposited nanoparticulate film but also to the continuous film with nano-sized grains. This is experimentally verified with vacuum-deposited metal thin films.

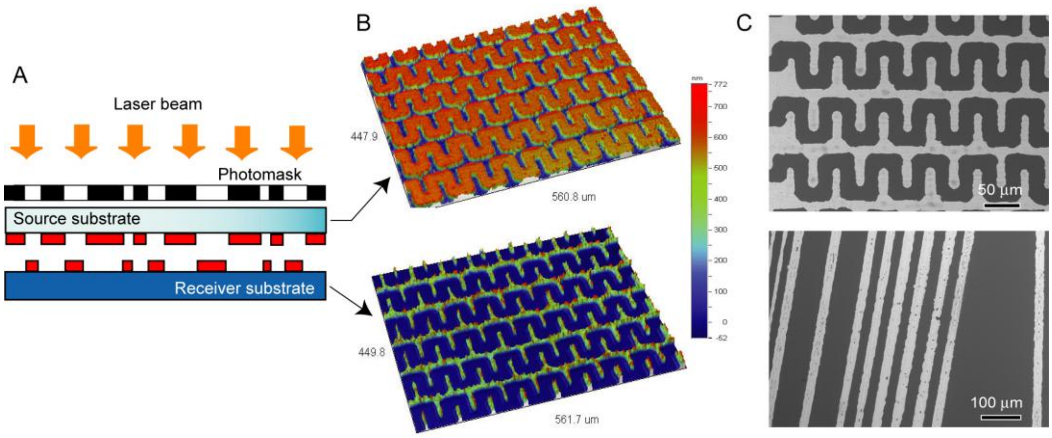

Fig. 1.

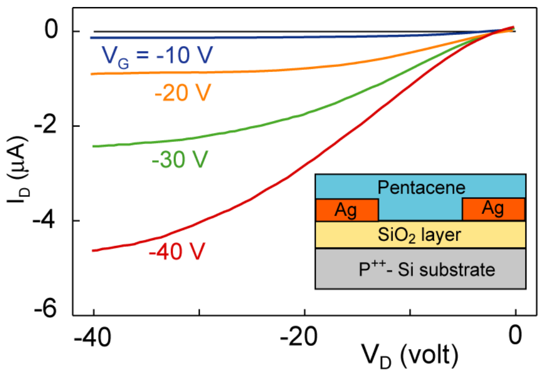

Fig. 2.

[1] H. Sirringhaus, T. Kawase, R. H. Friend, T. Shimoda, M. Inbasekaran, W. Wu, E. P. Woo, Science 290, 2123 (2000)
[2] B. Ridley, B. Nivi, J. M. Jacobson, Science 286, 746 (1999)
[3] G. H. Gelinck et al., Nature Mater. 3, 106 (2004)
[4] D. B. Mitzi, L. L. Kosbar, C. Murray, M. Copel, A. Afzali, Nature 440, 783 (2006)
[5] C. D. Dimitrakopoulos, P. R. L. Malenfant, Adv. Mater. 14, 99 (2002)