# Rapid ablation of polymer film and self-aligned formation gold nanoparticles by localized joule heating

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**Abstract**

A localized joule heating technology for rapid ablation of polymer thin film and self-aligned formation of gold nanopartilces (AuNPs) is reported in this study. The polysilicon thin film sub-microheater (figure 1(a)) was prepared by fully CMOS compatible technology; The sub-microheater was processed from starting with a p-type silicon wafer with 1000Å-thick thermal oxide. A 595Å-thick polysilicon film was deposited by LPCVD and patterned by the conventional lithography, and then it was implanted with Boron of 2.5e14 $cm^{-2}$ at 20 keV. The n+ region was implanted with Arsenic of 5.5e15$cm^{-2}$ at 30 keV. Subsequently, an oxide/nitride stack with thicknesses of 4/15 nm, respectively, was deposited sequentially by LPCVD. After inter-level dielectrics (ILD) deposition, dopants were activated at 930 ℃ for 30 min in the furnace. After forming the contact via, a metallization process was followed by forming gas annealing at 400 ℃. The sub-microheater consists of 5 parallel straight wires (each with 500 nm wide and 15 um long), as shown in figure 1(b). An IR camera (Infrascope, Quantum Focus Instrument Corporation, USA) was used to measure the temperature distribution. Operating under 1 mA, temperature of hot spot was estimated in the range of 350 ℃ as shown in figure 3(a). Although detail results are limited by spatial resolution (5 μm) and temperature range (50~350 ℃) of IR camera, it confirmed the temperature distribution obtained from simulation. Process flow of the self-aligned localized joule heating for AuNPs formation was shown in figure 2. A short voltage pulse (55V, 5 μs) causes significant localized joule heating and associated rapid and local ablation the PMMA thin film, as shown in figure 3(a). We expect that the maximum temperate of sub-microheater reach to at least 450 ℃ at the short duration.(In comparison, the sample was heated on a hot plate at 450 ℃ for 10 min to ablate PMMA thin film.) A layer of 2-nm thick gold film was then deposited on the sample by sputtering and followed by a lift-off process, which removes the PMMA thin film and leaves the gold film locally, as shown in figure 3(b). Again, applying a pulse (40V, 500 μs) for localized joule heating results in rapid thermal annealing of thin gold film and formation of AuNPs, as shown in figure 3(c). The proposed technique in terms of low power consumption, high heating speed, and localized heating is believed very useful in many applications.

References

1. I. Park, Z. Li, A. P. Pisano, and R. S. Williams, Nano Lett., 7, 3106-3111 (2007).
2. Y. C. Lin, J. Bai, and Y. Huang, Nano Lett., 9, 2234-2238 (2009)
3. O. Englander, D. Christensen, L. W. Lin, Appl. Phys. Lett. 82, 4797-4799 (2003)

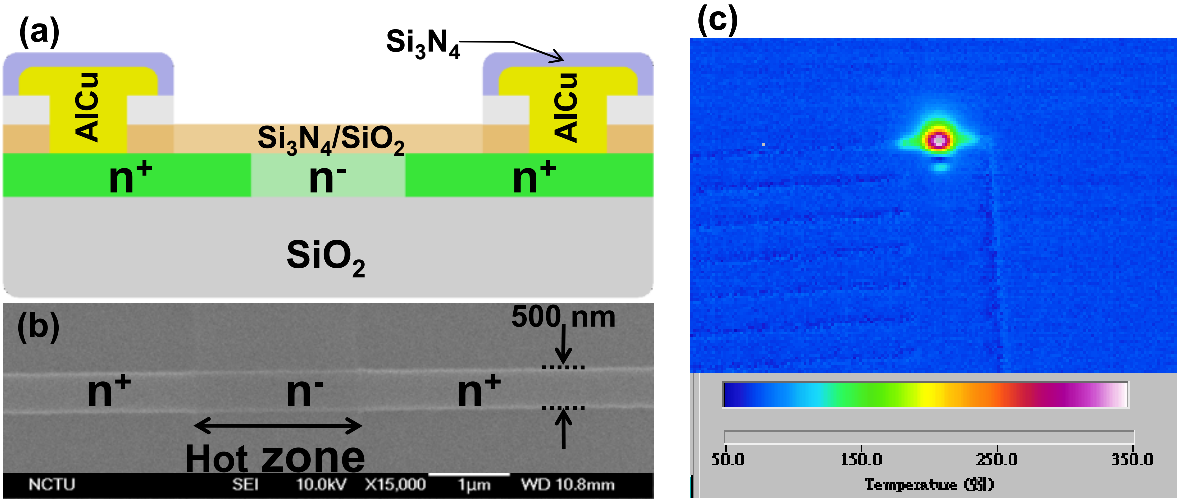


**Figure 1.** (a) Schematic of the cross section of the layered structure of devices. (b) Scanning electron micrograph of a microwire with different doping concentrations. (c) IR camera image of sub-microheater under a bias of 1 mA.

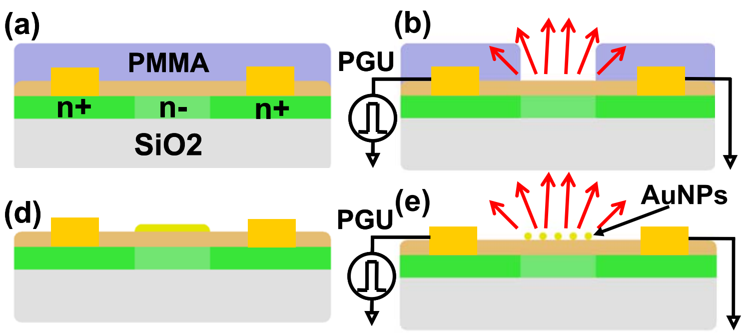


**Figure 2.** Cross-sectional schematic of the fabrication steps for self-aligned ablating PMMA thin film and formatting AuNPs by the localized joule heating. (a) Spin coating of PMMA layer. (b) Localized ablation of PMMA layer by the applying a short voltage pulse. (c) Deposition of a uniform gold thin film. (d) Lift-off for selective deposition of Au thin film. (e) Rapid thermal annealing via the second localized joule heating for the formation of AuNPs.

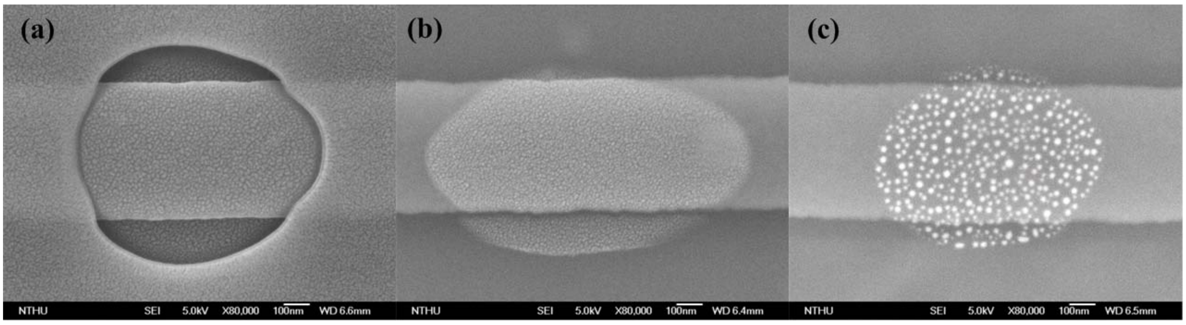


**Figure 3.** Scanning electron micrographs of (a) Localized ablation of PMMA layer. (b) Selective deposition of Au thin film via lift-off process. (c) Localized formation of AuNPs by the second joule heating.