NI-P: MICROSTRUCTURE AND MICRO-COMPRESSION

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Electroless nickel-phosphorus (EN-P) plating is a popular deposition process with widespread applications in microelectronics [1, 2]. Much emphasis has been given on the plating process and on the physical and chemical properties of the EN-P layers; however their mechanical properties down to the sub-micrometer dimensions have not been elucidated systematically. In this work, we study the mechanical properties of EN-P as a function of annealing states using in-situ pillar compression technique [3].

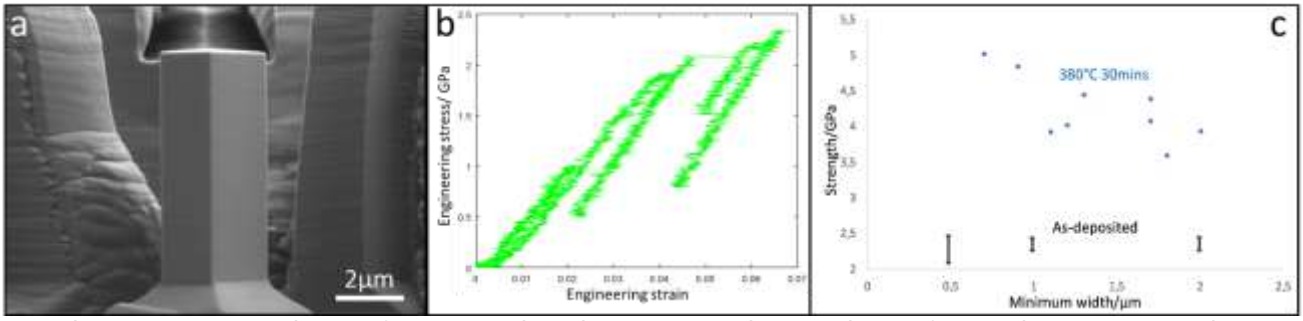

Figure 1 – a, SEM picture of a rectangular micro-compression specimen of EN-P; b, A representative engineering stress-strain curve of the micro-compression samples (from a sample with width of 2.3 µm); c, Overview of the strengths of the EN-P micro-compression samples as a function of their minimum sizes. The as-deposited samples show no size effect, while the samples annealed at 380 °C for 30 min show some trend of increasing strength when the sample size decreases. Note that each bar for the as-deposited samples depicts the distribution of the measured strengths of the corresponding sizes (9 samples of 500nm, 5 of 1µm and 4 of 2µm). For the annealed samples, the samples are with different sizes, so no statistical error bars are given.

The as-deposited EN-P films are found to be amorphous by XRD and TEM investigation. Micro-compression samples (Fig. 1a) with different dimensions but same aspect ratios are fabricated using focused ion beam and tested inside a scanning electron microscope. The samples all show linear elastic behavior, as evidenced by the stress-strain curves shown in Fig. 1b. Note that the strain includes the contribution from the sample as well as from the testing setup due to its compliance. The strengths of the three tested dimensions are within the error bars identical, documenting the absence of a size effect to 500 nm for the as-deposited EN-P films (see Fig. 1c).

The as-deposited EN-P films were then annealed for 30 min at 380°C to obtain crystallized Ni. In contrast to the as deposited material, the annealed samples show a possible size effect and much higher strength (blue data points in Fig. 1c). This different behaviour is primarily attributed to the nano-sized crystallized domains that function as barriers against the formation of shear bands propagating through the entire cross-section.

References

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