Supplementary Information 1: Inkjet Printed Superparamagnetic Polymer Composite Hemispheres with Programmed Magnetic Anisotropy†

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Composite Preparation

The superparamagnetic polymer composite (SPMPC) discussed in this work is derived from a superparamagnetic ferro fluid (FF) containing magnetite nanoparticles (Fe_3O_4, average diameter 11.4 ± 3.4 nm [1]) dispersed in γ-butyrolactone (GBL). The FF (particle concentration 264 mg/ml) is combined with epoxy type SU-8 photo resist to achieve a particle concentration of 2%vol with respect to the solid SU-8 content. GBL is added to achieve a dilution ratio of 1:4 (solid SU-8 content to GBL) to enable a viscosity suitable for inkjet printing. Uniform particle dispersion is realized by employing a Hauschild DAC 150 planetary mixer for 10 minutes and sonication in a Sonics & Materials Inc. Vibracell VCX 600 ultrasound system for 20 minutes.

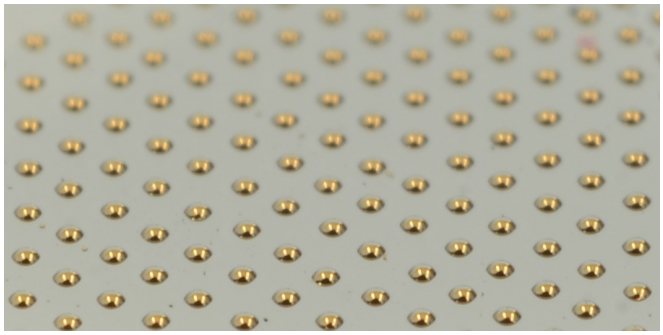

Fig. 1 Arrays of inkjet printed superparamagnetic polymer composite hemispheres. The diameter of the hemispheres is 250 μm.

Device Fabrication

The inkjet printing has been done using a Microdrop Technologies based inkjet printing setup [2]. Generating stable SPMPC microdrops requires an additional pre-sonication of 2 hours in a Transsonic 460/H ultrasonic bath done right before inkjet printing. The 25 pL generated drops have an in-flight diameter of 36 μm. The curvature and the size of the hemispheres are adjusted by controlling the surface properties of the substrate and the number of drops printed as described in [3]. Printing 10 and 50 drops on glass substrates involving an anti-sticking self-assembled monolayer (SAM) led to SPMPC hemispheres with diameters of 130 μm and 250 μm, respectively. Large arrays of hemispheres can be printed by this method. Fig. 1 and Fig. 2 shows hemispheres with 250 μm diameter. The magnetic easy axis of these capsules has been adjusted by carrying out all fabrication steps in the presence of a homogeneous magnetic field of 300 Oe. The magnetic field is generated by a custom made Helmholtz coil setup equipped with a micro hot plate [4]. Thermal curing of the printed capsules at 160°C enables composite cross-linking beyond the optical limit [5,6]. SPMPC capsules have been released using in a Transsonic 460/H ultrasonic DI water bath.

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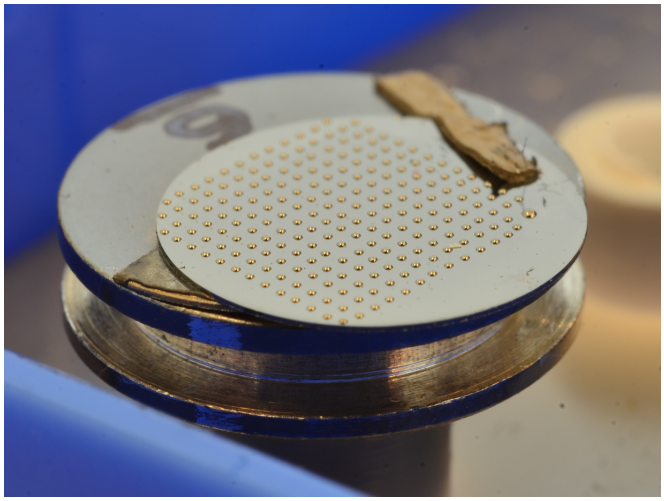

Fig. 2 Arrays of inkjet printed superparamagnetic polymer composite hemispheres on a 1 cm glass substrate prepared for SEM-FIB imaging. A thin gold coating (about 5 nm) is applied to the sample. The diameter of the hemispheres is 250 μm.

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