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Supplementary Information

Sol-gel magnetite inks for inkjet printing

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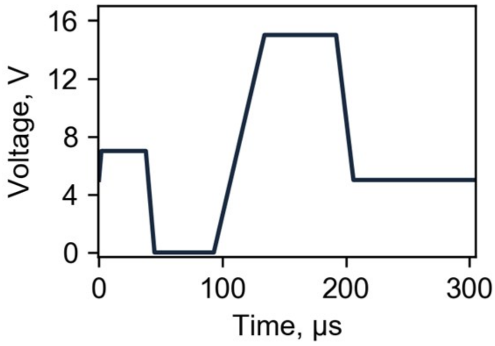

Figure S1 - waveform for printing process of the magnetite ink.

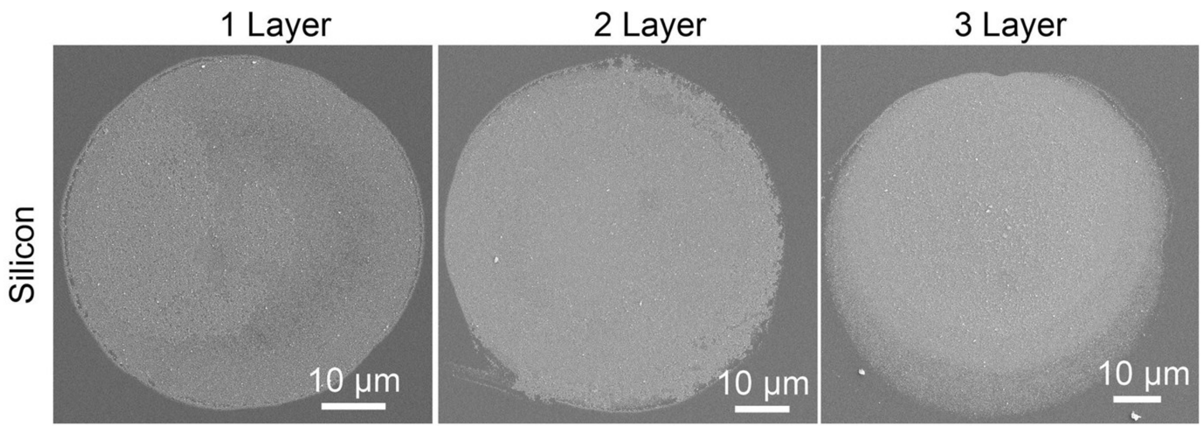

Figure S2 - SEM images of magnetite drops printed in 1 to 3 layers on silicon substrate

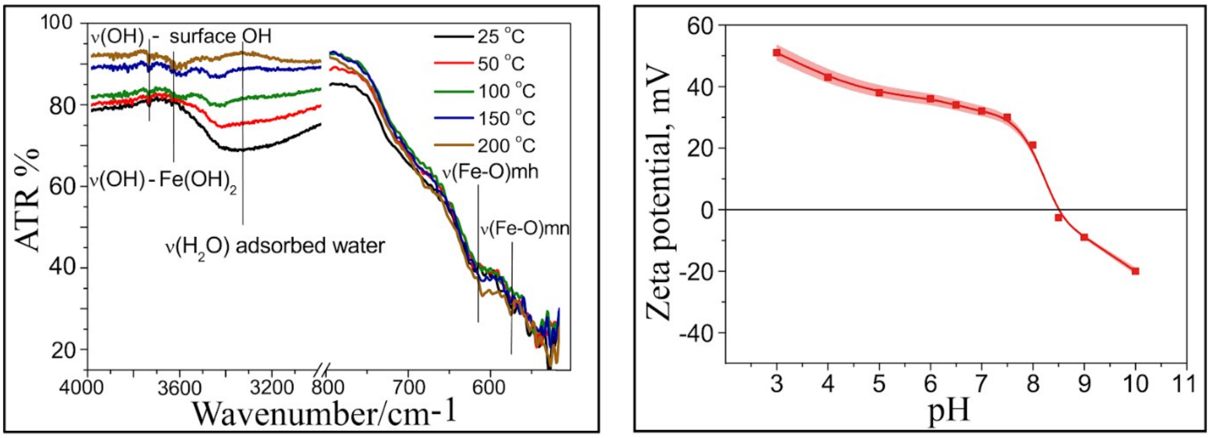

Figure S3 - IR spectra of magnetite at different temperatures (a); dependence of zeta potential value on pH level

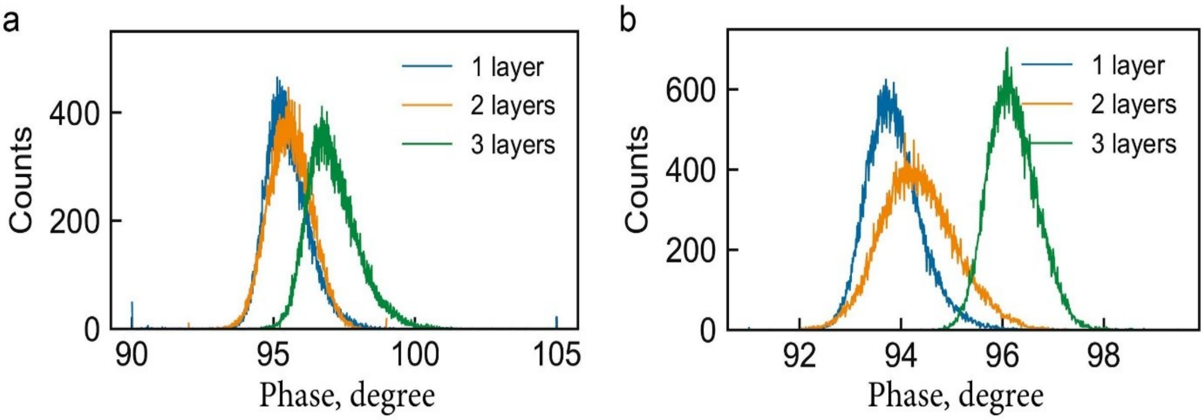

Figure S4 – Images of histogram of the change in the phase of oscillations a) centre of the drop b) coffee ring of the drop on the silicon substrate

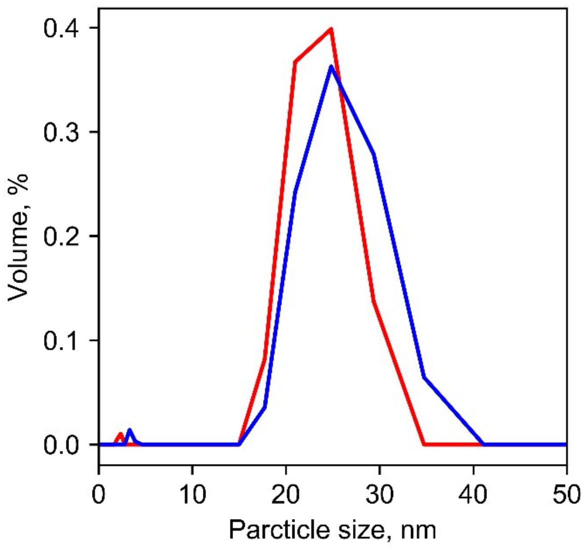

Figure S5 – Particle size distribution over time, red line – after formulation the ink, blue line – after 30 days.

Inkjet printing of holographic patterns

Inkjet printing of a holographic pattern was performed with substrate table heating to 40 C, without drying between layers, the drop spacing was 50 µm.

Measurement of magnetic properties.

The magnetic properties of the samples were measured using dynamic magnetic force microscopy (MSM) using a two-pass technique using the Ntegra Aura probe microscope (NT-MDT, Russia). On the first pass extracted information about the terrain, whereas during the second pass at a fixed height from the surface of the sample (characterized by $\Delta Z \approx 10$ nm) have been registered magnetic of moles in the phase change of oscillation of the probe. Mfm01 probes (NT-MDT, Russia) with a magnetic sputtering thickness of 30-40 nm CoCr and a characteristic radius of curvature of the top of 40 nm were used . When measuring the distribution of magnetic moles, the magnetic probe oscillates at its characteristic resonance frequency $f_0 \approx 70$ kHz above the sample surface.

Visualization of the magnetic field structure on the surface of the sample was carried out by a two-pass method using the phase contrast mode by measuring the additional phase shift that occurs between the oscillations of the piezovibrator and the vibrations of the probe in the presence of a magnetic field gradient.

The force acting on the probe is determined by the energy gradient of the interaction of the magnetic moment of the probe with the magnetic field of the sample and, ultimately, depends on both the gradient of the magnetic field of the sample and the dependence of the magnetic moment of the probe on the coordinates:

$$F_z^{'} = \frac{\partial F_z}{\partial z} = \int_V \left(M_x \frac{\partial^2 H_x}{\partial z^2} + M_y \frac{\partial^2 H_y}{\partial z^2} + M_z \frac{\partial^2 H_z}{\partial z^2} \right) dV$$

where *z* is the direction perpendicular to the surface of the sample; *x,y* are the directions lying in the plane of the sample; *M (x,y,z)* is the magnetic moment of the probe; *H (x,y,z)* is the magnetic field strength (integration is carried out by the volume *V* of the magnetic probe).

The presence of the gradient in the strength $F_z^{'}$ of leads to a shift of the resonant frequency and phase $\Delta\varphi$ of the oscillations of the probe of the properties of the probe and the magnetic field of the sample.