Electronic Supplementary Information to an article:

'Stable colloids of strontium hexaferrite hard magnetic particles'

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Section S1. Preparation of glass-ceramics and strontium hexaferrite colloids.

The initial glass compositions were $14SrO$-$6Fe_2O_3$-$12B_2O_3$ (glass G) and $4Na_2O$-$9SrO$-$5.5Fe_2O_3$-$4.5Al_2O_3$-$4B_2O_3$ (glass GA). The starting reagents ($SrCO_3$, Fe_2O_3, Al_2O_3, B_2O_3 and $NaHCO_3$, high purity grade) were mixed in the corresponding ratios and melted for 2 h at 1250°C in a platinum crucible. The melts were quenched between two rotating steel rollers to obtain amorphous glass. Then the glass G was heated to 680 or 740°C with a rate 5°C/min and rapidly cooled to room temperature. The corresponding glass-ceramic samples were labeled as G680 and G740. The glass GA was isothermally annealed at 700 and 750°C for 2 h, and corresponding glass-ceramics were labeled as samples GA700 and GA750. Powder X-ray diffraction analysis confirmed the presence of $SrFe_{12}O_{19}$ phase in all samples. Also metastable SrB_2O_4 (PDF 33-1321) and stable SrB_2O_4 (PDF 84-2175) borate crystalline phases were detected in G680 and G740 glass ceramics, correspondingly. GA700 and GA750 contained $Sr_2B_2O_5$ (PDF 73-1930), $SrAl_2O_4$ (PDF 31-1336) and $SrFeO_{3-x}$ (PDF 34-0641) crystalline phases in addition to hexaferrite.

To obtain hexaferrite colloidal solutions the glass-ceramics were treated with hydrochloric acid. In a typical experiment about 50 mg of glass-ceramic powder were placed in a 50 ml plastic test-tube which was then filled with 3% HCl and ultrasonically shaken at 60°C for 15 min. After that the magnetic phase was precipitated by a NdFeB magnet, and the supernatant solution was removed by decantation. The precipitate was dispersed in water and ultrasonically treated. The resulting colloids were placed near a magnet again for 1 h to separate particle aggregates and obtain transparent red-coloured solutions. The corresponding colloids were marked as F680, F740, FA700 and FA750.

Section S2. Sample Characterization Techniques.

Powder X-ray diffraction studies (XRD) were performed using a Rigaku D/MAX 2500 diffractometer (CuK_α radiation). Energy-dispersive X-ray spectroscopy (EDX) was carried out on scanning electron microscope Leo Supra 50VP equipped with Oxford Instruments Energy+ detector.

Transmission electron micrographs and electron diffraction patterns were obtained using a LEO 912 AB Omega microscope. The diameter of platelet-like particles was defined as the largest dimension of basal plane of the particle. The diameter and the thickness are simultaneously visible from the side view of the particles. More than 300 particles were measures for every sample to obtain the mean values.

The magnetic properties were studied with Quantum Design MPMS-7 (AC measurements) and Cryogenic S700 (DC measurements) SQUID magnetometers. The colloidal solutions were characterized by dynamic light scattering (DLS) on a Zetasizer Nano ZS (Malvern Instruments) with backscattering configuration, and correlation data were fitted using the DTS software package. The magneto-optical measurements were performed using a Helmholtz coil device producing the DC magnetic fields up to 180 Oe and AC magnetic fields with 4 Oe amplitude and 1 kHz maximum frequency. A Xe-lamp was used as a light source in DC measurements and the transmitted spectra were measured using an OceanOptics QE65000 spectrometer in the wavelength range 400 – 800 nm. In the AC experiment a laser with wave-length of 532 nm was used as a light source and a PIN photodiode as a detector.

Section S3. Tables.

Table S1. Lattice parameters of hexaferrite particles.

Sample	*a*, Å	*c*, Å
$SrFe_{12}O_{19}$*	5.8844(6)	23.050(3)
F680	5.884(2)	23.04(1)
F740	5.885(4)	23.04(1)
FA700	5.852(5)	22.93(1)
FA750	5.851(3)	22.93(1)
* [PDF 84-1531] X. Obradors, et al. J. Solid State Chem., V.72, P.218.		

Section S4. Figures.

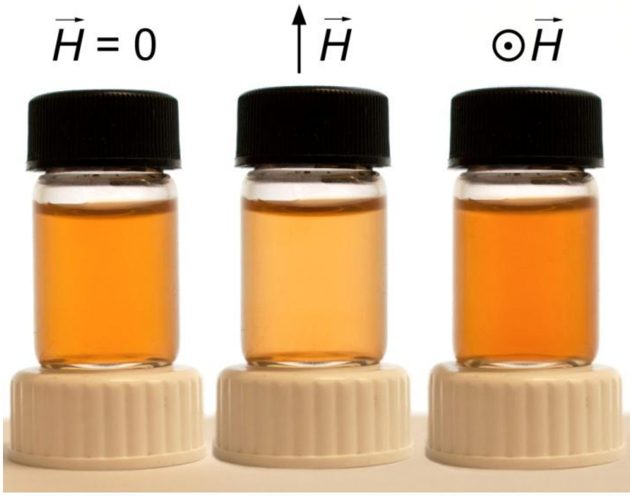

Fig. S1. Strontium hexaferrite colloids.

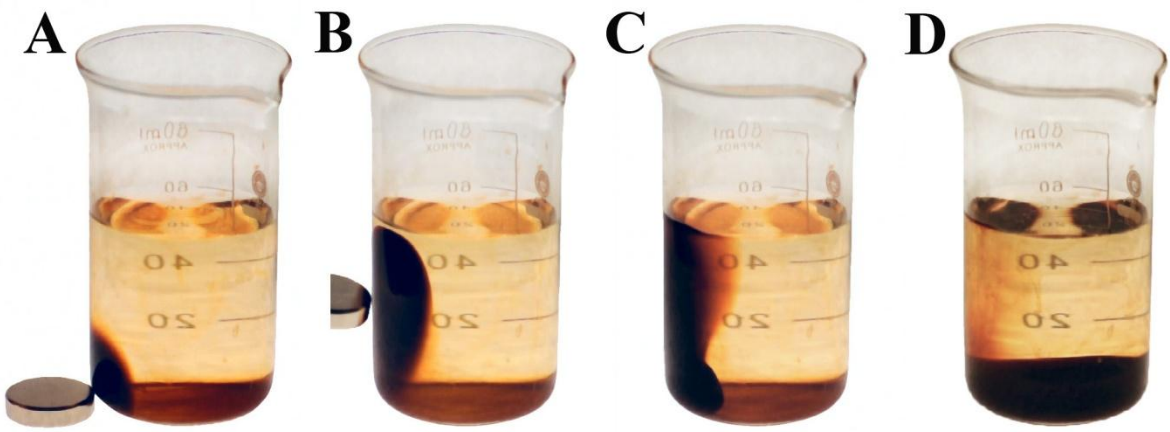

Figure S2. Separation of concentrated liquid phase in FA750 sample after prolonged exposure to inhomogeneous magnetic field of NdFeB magnet (A). Behavior of the phase in the presence (B) and absence (C, D) of the magnetic field.

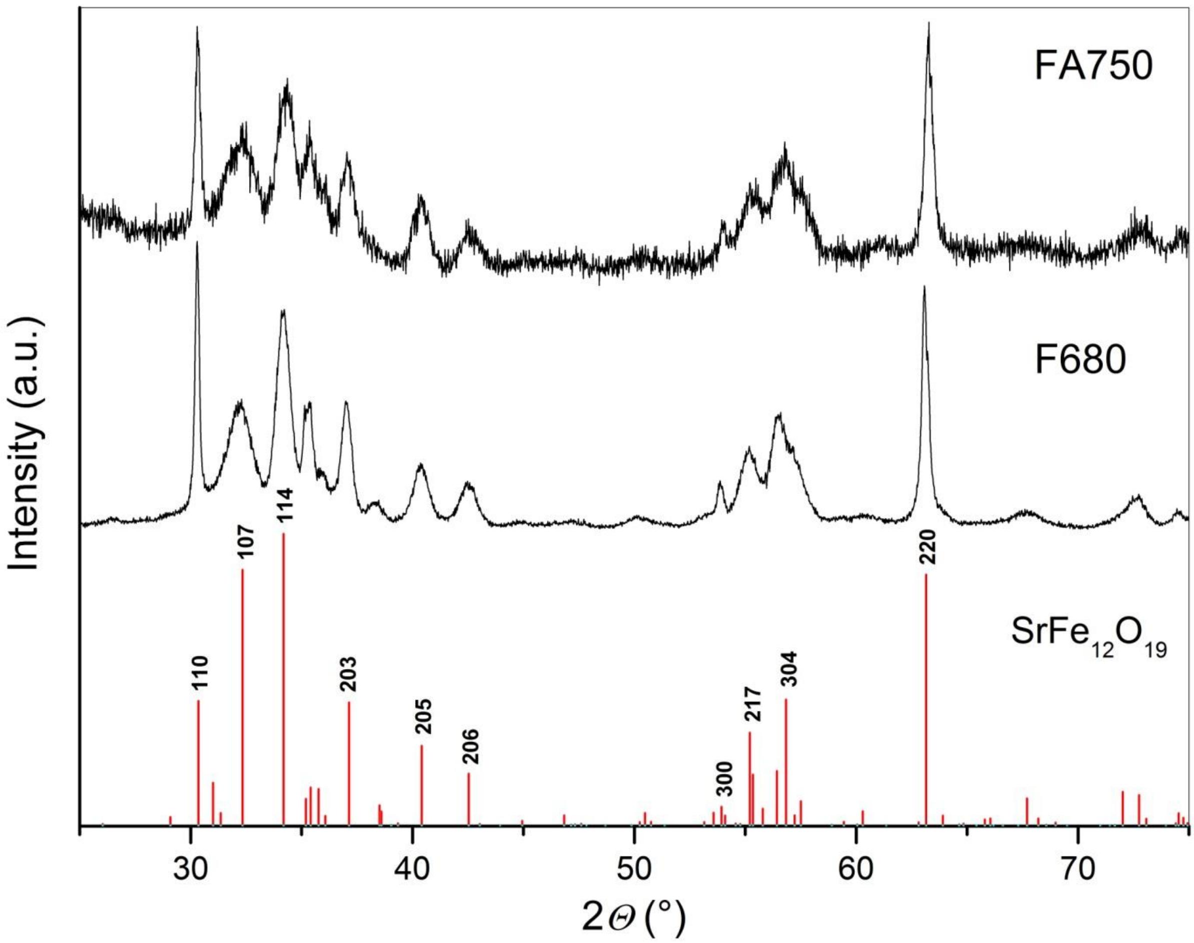

Figure S3. XRD patterns of dried colloidal particles in comparison with $SrFe_{12}O_{19}$ diffraction lines (PDF- 84-1531).

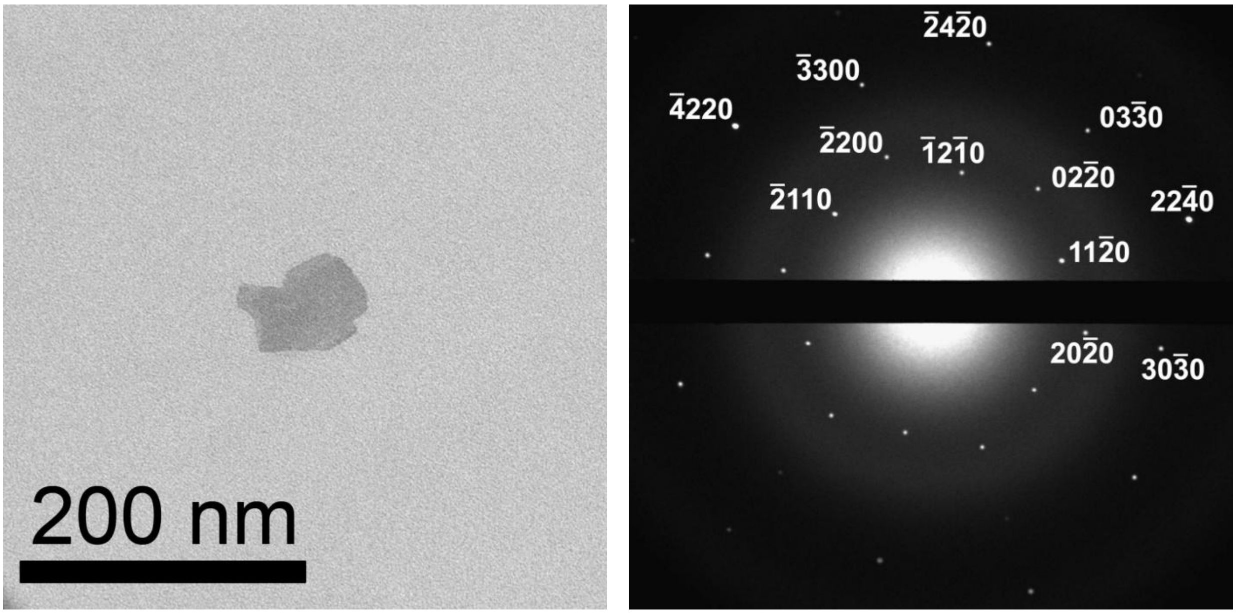

Figure S4. Single colloidal particle and corresponding electron diffraction pattern (electron beam is normal to the particle basal plane) with marked strontium hexaferrite reflections.

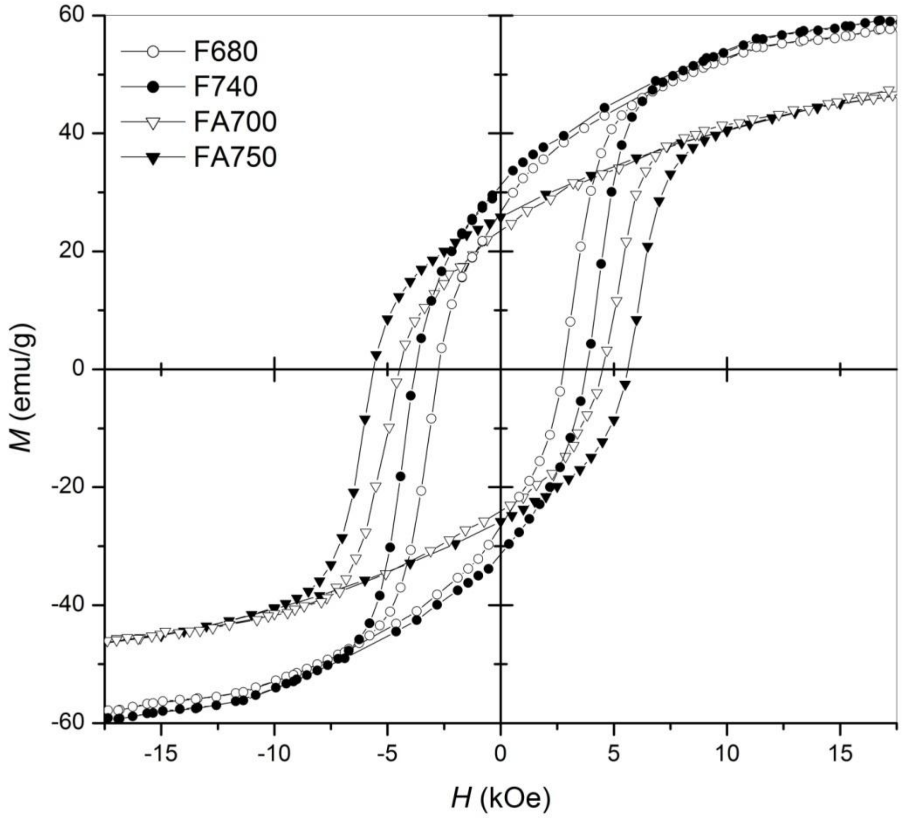

Figure S5. Hysteresis loops of dried colloidal particles.

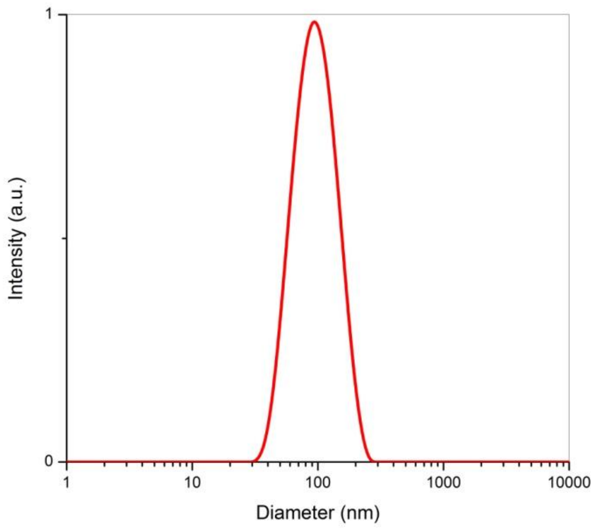

Figure S5a. Intensity distribution of hydrodynamic diameters of colloidal particles in FA750 sample (DLS).

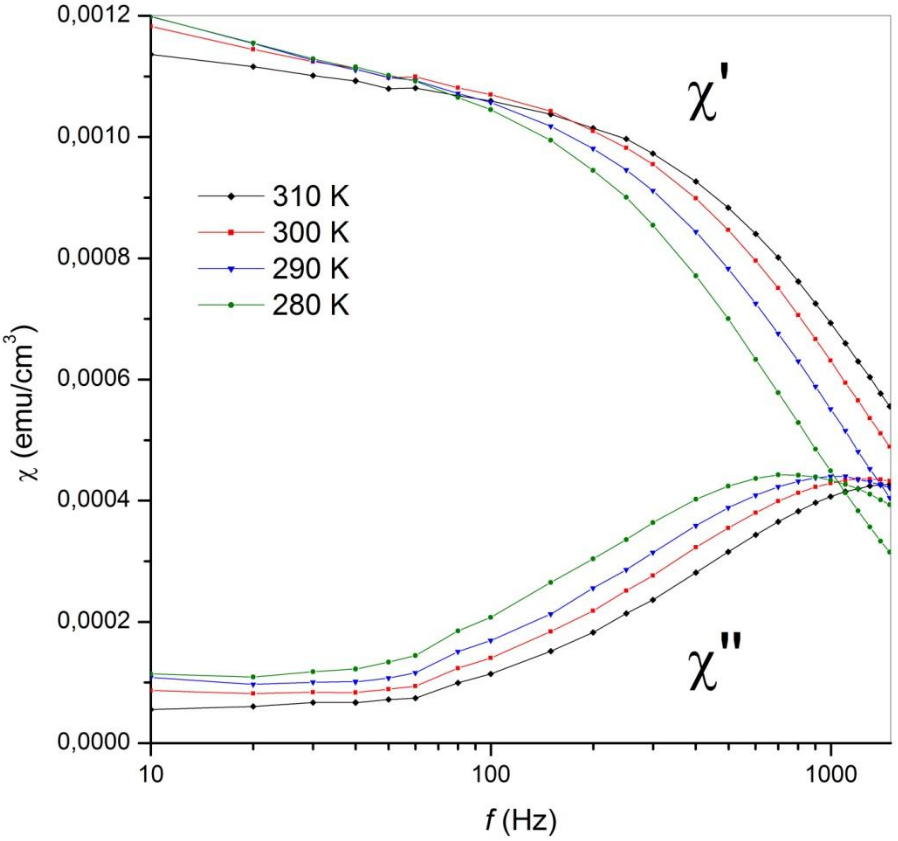

Figure S6. AC-susceptibility measurements of F680 sample (field amplitude of 4 Oe).

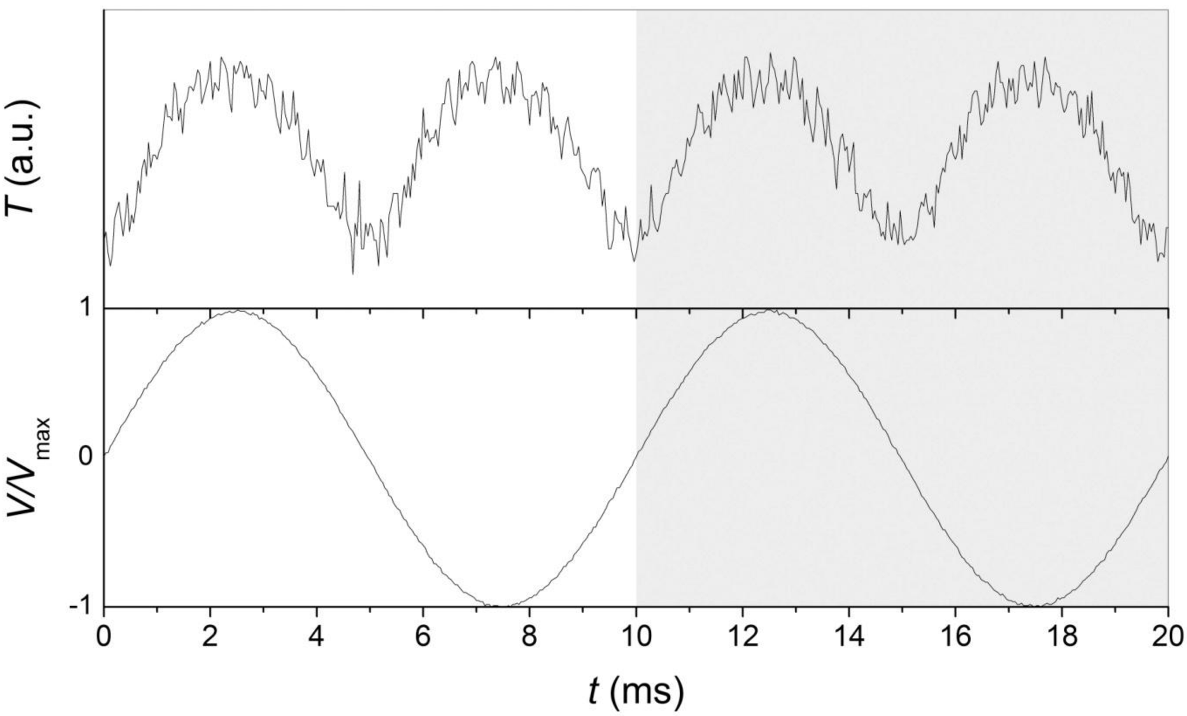

Figure S7. Optical oscillations under an alternating magnetic field (100 Hz, 4 Oe). Optical response changes with doubled frequency compared with the supplied voltage of Helmholtz coil.

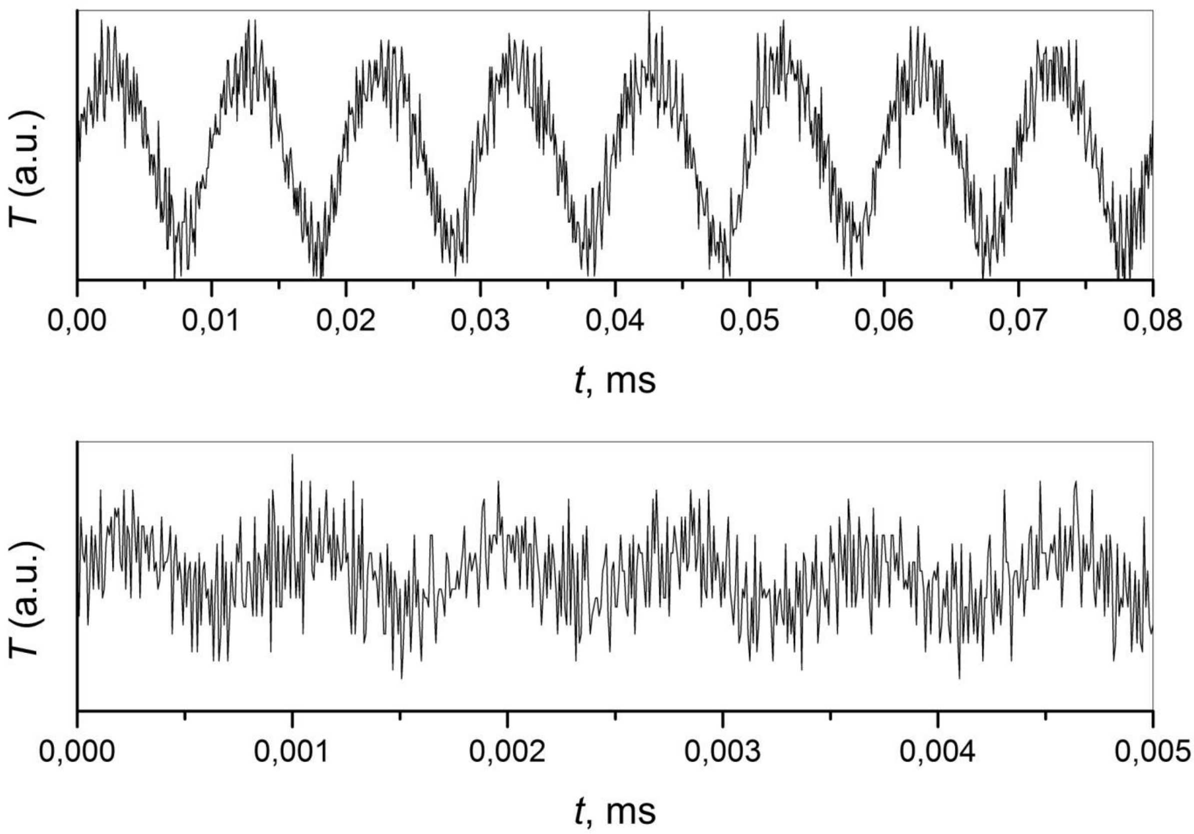

Figure S8. Optical oscillations under 50 Hz (top) and 600 Hz (bottom) AC magnetic field.