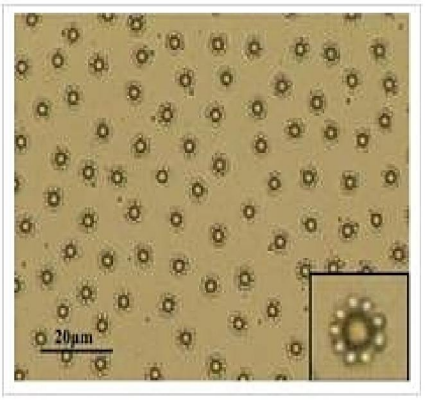
Magnetic nanoparticles for medical diagnostics

Adarsh Sandhu, University of Electro-Communications, Tokyo

E-mail: sandhu@uec.ac.jp

Gadolinium-based paramagnetic nanoparticles play a critical part in high enhancing the contrast of magnetic resonance imaging (MRI). Such 'contrast agents' are injected into the blood stream of patients prior to MRI examination. The magnetic particles yield high contrast images of the brain and other organs due to the interaction of the large magnetic fields applied during MRI with the iron oxide particles circulating in the blood stream.



Such contrast agents are an example of the unique applications of magnetic particles for medical diagnosis of ailments such a cancer. Here, I will describe my group's research on the use of magnetic nanoparticles as 'magnetic labels' for medical diagnostics. Specifically, I will describe the integration of Hall effect magnetic field sensors and magnetic nanoparticles for point of care biosensing protocols based on InSb/InAs and GaAs/AlGaAs Hall devices for sensitive and rapid detection of superparamagnetic beads [1,2,3].

Intriguingly, paramagnetic nanoparticles form robust 'chains' under external magnetic fields. We have exploited this phenomenon to develop 'label-less homogenous' medical diagnostic procedures—magneto-optical transmission sensing—where the optical transmission of a colloid containing rotating chains of magnetic of nanobeads enables the detection biomolecules with pM-level sensitivity with a dynamic range of more than four orders of magnitude [4].

I will conclude by describing biosensing based on magnetically induced self-assembly of superparamagnetic beads and nonmagnetic beads, and new ideas for 'magnetic washing' and biosensing with fluorescent magnetic nanobeads [5,6]

References

1. A. Sandhu, 'Biosensing: new probes offer much faster results', Nature Nanotechnology 2, 746 (2007).
2. Adarsh Sandhu, Hideaki Sanbonsugi, Ichiro Shibasaki, Masanori Abe and Hiroshi Handa, "High Sensitivity InSb Ultra-Thin Film Micro-Hall Sensors for Bioscreening Applications", Jpn. J. Appl. Phys. 43 L868, (2004).
3. A. Sandhu, M. Abe and H. Handa, 'Magneto-Optical Biosensing Platform Based on Light Scattering from Self-Assembled Chains of Functionalized Rotating Magnetic Beads', Nano Lett. 10, 446 (2010).
4. A. Sandhu, M. Abe, and H. Handa, 'Synthesis and applications of magnetic nanoparticles for biorecognition and point of care medical diagnostics, Nanotechnology 21, 442001 (2011).
5. Ye Yang, Y. Morimoto, T. Takamura, and A. Sandhu, 'Biosensing Based on Magnetically Induced Self-Assembly of Particles in Magnetic Colloids', Journal of Nanoscience and Nanotechnology, 12, (2012).
6. Jaiyam Sharma a, Shunji Ishizawa, Ryoji Yukino, Tsukasa Takamura, Naohiro Hanyu, Hiroshi Yasuno, Hiroshi Handa, Adarsh Sandhu, "Fast and sensitive medical diagnostic protocol based on integrating circular current lines for magnetic washing and optical detection of fluorescent magnetic nanobeads", Sensing and Bio-Sensing Research 9, 7–12 (2016).