Fabrication of small glass capsules incorporating quantum dots

Toward practical use as fluorescent reagents for bio-applications utilizing their high brightness and photo-durability

We have developed small glass capsules incorporating multiple CdSe/ZnS quantum dots (QDs) that show bright photoluminescence (PL). The capsule can be used as a fluorescent reagent in a variety of bio-applications. Its brightness and durability could make it useful as a phosphor for electronics as well.

Among QDs, a CdSe/ZnS QD is advantageous in brightness, however, it easily agglomerates. To prevent this, polymer-coated QDs are commercially available. But it is difficult to further increase their brightness. It is advantageous to encapsulate the QDs in glass which is more durable than polymers.

We have worked to develop a QD-dispersed glass capsule with a diameter of less than 100 nm by the Stöber synthesis, a kind of sol-gel method using alkoxide, since the particle of this size is critical for easy endocytosis by cells. Utilizing the properties of alkoxides, we have succeeded in incorporating multiple QDs in a glass capsule. The 50-nm capsule has brightness of about 10 times, light resistance of about 100 times, and cadmium leaching in a buffer solution of less than one-tenth, when compared with those of polymer-coated QDs.

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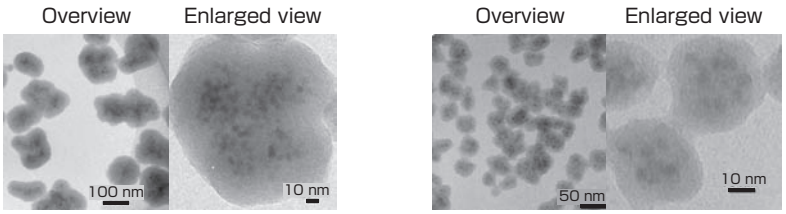

Transmission electron micrographs of the photoluminescent glass capsules with many dispersed CdSe/ZnS QDs
Left: Large capsules (95 nm in diameter) Right: Small capsules (40 nm in diameter)

A perpendicularly magnetized TMR element enabling the increase of the capacity of Spin-RAMs (MRAMs)

Design of Spin-RAMs of 5-Gbit or more is feasible

We have developed a high-performance perpendicularly magnetized TMR element that functions as a memory cell for large-capacity Spin-RAMs. In order to develop a large-capacity Spin-RAM with a memory capacity of over 1 Gbit, it is necessary to develop a perpendicularly magnetized TMR element that has not only a magnetoresistance (MR) ratio higher than 50 % to generate a large output signal, but also low resistance-area (RA) product of less than 30 $\Omega\mu m^2$ for impedance matching with peripheral circuits. However, there have been no reports on such perpendicularly magnetized TMR elements. The perpendicularly magnetized TMR element developed at AIST has succeeded in achieving an MR ratio as high as 85 % in a low-RA product region as low as about 4 $\Omega\mu m^2$. This technology enables the circuit design of large-capacity Spin-RAMs of 5 Gbit or more.

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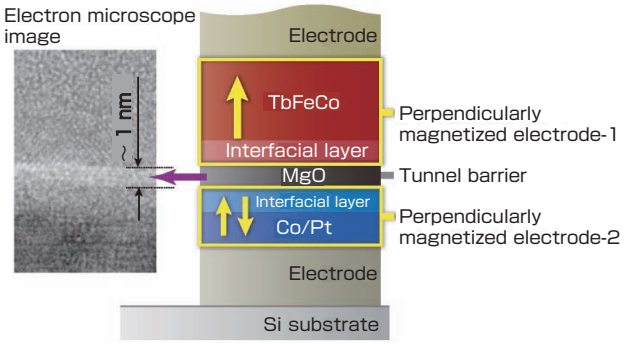

Electron microscope image of a cross-section of the perpendicularly magnetized TMR element developed (left), and a schematic of the cross-sectional structure (right)
The development of ultra-thin film planarization technology and a high spin-polarization inducing interfacial layer has led to success in achieving both a very low RA product and a high MR ratio.