The researchers hypothesized that mirrors based on epitaxial AlGaAs heterostructures might provide a path to reduced mechanical damping—and thus reduced thermal noise—while still providing ultrahigh reflectivity. Using molecular beam epitaxy, they deposited alternating layers of monocrystalline GaAs and $Al_{0.92}Ga_{0.08}As$ on a GaAs substrate. Then, using a lithographic process, the researchers formed 8-mm-diameter, high-reflectivity discs, which they removed from the growth wafer and direct-bonded to both planar and curved amorphous silica substrates. Next, using a Sr lattice clock laser with record frequency stability and an Yb fiber frequency comb, they measured the noise properties of an optical cavity formed from these mirrors. In close agreement with theory, they found a reduction of at least a factor of 10 in the coating noise at 1 Hz compared to state-of-the-art SiO_2/Ta_2O_5-based mirrors.

The results suggest that a new generation of room-temperature, ultrahigh-precision measurements may now be possible in atomic clocks, gravitational-wave detectors, and other systems. The researchers said that the fabrication technique does not appear to have any fundamental limits to achieving larger mirror sizes, and relatively simple techniques can likely be applied to tailor these mirrors to a wide range of wavelengths.

Colin McCormick

Bio Focus

Hard talk to stem cells for new bone growth

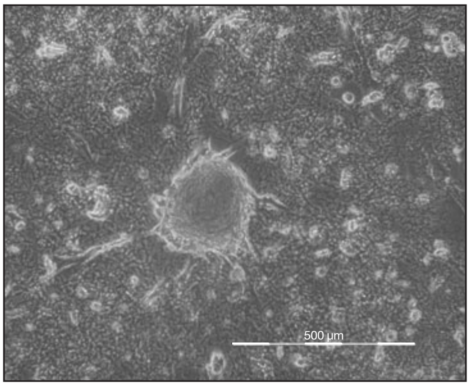
Synthetic materials have widely enabled medical repairs and replacements for damaged bones, such as in the use of fracture-supporting metal rods and artificial hips. These biomaterials are rapidly improving, but suffer from several limitations: they call for invasive surgery, are associated with painful recoveries, and lack the capacity to organically self-heal. With new developments in stem cell biology, tissue engineers dream of overcoming these traditional biomaterial limitations by ultimately regrowing injured bones, good as new.

The opportunity arises from the natural ability of stem cells to differentiate (i.e., transform themselves) into new bone-growing cells called osteoblasts, but the challenge lies in successfully coaxing this transformation to occur when, where, and in the way that one desires. A.H. Ambre, D.R. Katti, and K.S. Katti of North Dakota State University have recently approached this challenge by exploring the use of clay-based composites as potential scaffold materials for bone regeneration.

An ideal scaffold material would support the growth of stem cells, induce their differentiation to osteoblasts, and template osteoblast-directed mineralization into the desired bone-like biomaterial. In practice, achieving a scaffold that performs these functions is highly challenging, as stem cells respond differently to differing material surface structures and chemistries, and design rules are elusive at present.

In an article published in the September issue of the *Journal of Biomedical Materials Research A* (DOI: 10.1002/jbm.a.34561; p. 2644), the research team provides evidence that films comprising combinations of sugar derivatives (chitosan and polygalacturonic acid), alumino-silicate clay nanoparticles, and hydroxyapatite (HAP) may induce the differentiation of mesenchymal stem cells into osteoblasts on the film surfaces. The study shows that the method selected for composite synthesis affects the cell-directing properties of the resulting films, and determines whether the clay material makes a difference. If clay and HAP particles are added to a premixed solution of the two biopolymers, the resulting composite seems to support increased stem cell growth and differentiation relative to control materials with no clay-based mineral. However, if the mineral fraction is combined with chitosan first, followed by polygalacturonic acid addition, the clay-containing composite shows little difference in influencing cell behavior relative to clay-free counterpart materials.

These results are consistent with the researchers' prior work, which showed that polymer interactions at clay surfaces induce an "altered" nanoscale polymer phase near the mineral surface. The nature of these polymer-altering interactions would depend on the polymer's charged groups (e.g., amines and carboxylates), and distributions and availabilities of such groups will change if distinct polymers are first combined.



Mesenchymal stem cells grow on a clay-containing scaffold material. Reproduced with permission from *J. Biomed. Mater. Res. Part A* (2013), DOI: 10.1002/jbm.a.34561; p. 2644. © 2013 Wiley Periodicals, Inc.

The prospect of directly controlling stem cell differentiation with specially designed composite surfaces is attractive, as this would place biological control in the hands of materials engineers, and bypass the need for soluble chemical signals that are typically used to induce stem cell differentiation experimentally. Further, by appropriately tuning mechanical properties—through mineral additives such as clay, for example—scaffolds could be designed to support biological loads while stem-cell-directed bone growth is still in progress. Tissue engineers thus have a real incentive to study and tune clay–polymer interactions. Perhaps this will one day lead to designer surfaces that convincingly "talk" to stem cells, persuading them to pursue new lives as full-fledged biological bone.

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