Nanotechnologies and nanosciences, knowledge-based multifunctional materials & new production processes and devices

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Production processes

- Making the 3D image
- Building up the object
- Market potential

Fine art copies from marble dust

Technology developers and museums collaborated in ECOMARBLE to develop an innovative process to reproduce artefacts from marble dust. The process also has potential in decoration and architecture.

Museums are keen to make exact copies of ancient sculptures that are too fragile to be handled. At the same time, good marble is getting scarce while waste marble dust piles up in quarries. In the European Commission-funded ECOMARBLE project, museums and technologists worked together to develop a method that combines remote measurement and a novel layering technique to build up a three-dimensional (3D) replica of an ancient object using marble dust.

While the marble quarries of Greece, Italy and Egypt have already surrendered much of their best stone, the chips, poorer stone and dust resulting from cutting have found little use other than in road making and aggregates for construction. Polyline of Thessaloniki, Greece, had the idea to use its expertise in 3D imaging as the basis of a new method to use this waste material in copying stone museum exhibits.

The company formed an international consortium with the Fraunhofer Institute (IFAM) in Bremen, Germany and Materialise of Belgium, together with the Focke Museum in Bremen, the Fitzwilliam Museum in Cambridge, England, and the Hellenic Ministry of Culture. "We aimed to make the highest quality copies of museum originals, as well as to produce consumer goods and cultural objects that look exactly like natural stone," says Polyline's Sofia Theodoridou.

▲ TOP

Making the 3D image

Ancient marble should not be handled, to prevent contamination or even breakage. So copying requires an image-maker that is not only non-contact, but can also be carried easily to the object, wherever it is. The technique used in ECOMARBLE combines laser scanning and digital photogrammetry.

In making an image of a marble bust, for instance, a reference grid is projected onto the object. This grid provides co-ordinates for a dense cloud of reference points obtained by two digital cameras working together but at different angles. The number of different sets or 'patches' needed to digitise the image depends on the surface complexity of the

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Special point-cloud handling software then calculates the patch data to derive a complete 3D model of the bust, which is then refined manually.

Building up the object

"The rapid prototyping process that converts the virtual image into a solid object is the most novel part of the ECOMARBLE development," explains Dirk Hennigs of the Fraunhofer Institute. It forms the object from thin layers of marble powder spread on a base plate. An applicator head similar to those in ink jet printers travels over each layer, following the computer data to apply a liquid binder across the required section. The binder soaks into the powder and is set by a heating lamp. Then the plate is lowered, ready for the next layer.

"We did some work to optimise the particle size of the marble," adds Hennig. "We found that a fine powder having a mean particle size of about 40 µm, with as little as possible below 10 µm, gave the best result."

The first test pieces were accurate reproductions with a good white colour, but not strong enough and rather porous. The Institute therefore looked at different hardening fluids to saturate the products, giving them greater mechanical strength and a more resistant surface. The most suitable proved to be an epoxy resin, which could be applied under a vacuum so that it penetrated further into the marble composite.

One of the first test pieces was an ancient head of the Greek goddess Hygeia, about 12 cm high. After the epoxy stabilising treatment, the head was very hard, shock resistant and felt like stone to the touch. It was stable to temperature change, humidity and ultraviolet light, none of which caused visible changes. A finishing process such as grinding or polishing could also be used.

"The rapid prototyping, which we call EcoArts, can make strong, stable artefacts that look like real stone," concludes Hennigs. "It can be also used with metal powders such steel, aluminium and titanium, which can be set by sintering at 1000°C."

▲ TOP

Market potential

"Museums like to be able to sell replicas," says Sebastian Watt of the Fitzwilliam Museum. "They spread our name around the world and encourage future visitors, as well as bringing in income. These replicas are very high quality and contain far more stone than the usual resin copies. They are also more economical than hand-carved copies, where labour is expensive. The process is being scaled up for much larger objects, which could be used to replace fragile originals where they are exposed to pollution. Friezes, for example, could be made by EcoArts while the originals were displayed indoors in a protected environment."

Watt believes that the process could have wider application than the somewhat fragmented museum market. "It is the image that sells, not the way it is produced," he says. "Why not a limited edition of Rodin's 'The Kiss' or the Eros statue in Piccadilly Circus, which could fetch high prices? Genuine marble is running out and this material could be used to make original sculptures. A greater potential use is in building components, marble tiles or household architectural features."

Meanwhile in Greece, Theodoridou has plans for the 2004 Olympic Games. "We hope that visitors will be able to buy replica antiquities and medals to commemorate the event," she concludes.