Training Opportunity for Irish Trainees

Reference	Title	Duty Station
IE-2019-TEC-QEE(2)	**4D Printing Reversibility & Space Evaluation**	**ESTEC**

Overview of the unit's mission:

The Materials' Physics and Chemistry Section is responsible for assessing all material w.r.t their physical and chemical properties and property evolution for ESA's mission. This entails a detailed understanding of effects caused by the environment (ground/space). The section operates a state of the art laboratory offering a wide selection of analysis and characterisation instruments as well as space simulation facilities to evaluate materials versus the effects of the space environment (vacuum, radiation, temperature, contamination, ATOX, charging etc.)

Overview of the field of activity proposed:

Additive manufacturing or 3D printing is a technique in which complex structures can be built layer by layer. Additive manufacturing enables the use of 3D printable 'smart materials' that can transform in a pre-programmed way in response to an external stimuli. This is known as '4D printing', with the fourth dimension referring to time. The applications of self-transforming structures are evident across all industries, in medical, defence and aerospace sectors, such as in-space deployable solar panels, composite hinges and antennas. The current materials capable of '4D printing' deliver exciting proof of concepts for future designs. The design of a deployment mechanism with fewer components, may have a lower risk of mechanical failures, and could potentially be cheaper, and simpler to control. However further development and qualifications are needed for their use in the space environment. Deployment mechanisms may have to operate only once or multiple times throughout their service life and the reliability and precision of deployment is paramount; thus understanding how 4D printed materials behave in microgravity, their fixity, repeatability and reversibility is an important and pressing challenge. 4D printing is at a proof of concept stage that has taken a huge step forward in realising the capabilities of pre-programming matter which react to a range of activation methods.

Allowing a structure to be printed and stored, to be assembled on demand, has many advantages, a single rod can be transformed into a structure, enabling assemblies much greater than the build tray to be produced. Significant savings are reported, in terms of time and material usage when printing a part flat packed, which can later be transformed. A FDM high temperature (420ºC) dual extruder which is capable of printing space qualified materials PEEK, PEKK, PEI, FEP - and other high strength thermoplastics, can also be utilized to print a variety of proof of concept composite structures, to test bilayer compatibility. Test methods for space material standardization and environmental testing, covering the ground as well as space are needed, and the following should be taken into consideration;

- The effects of long term storage on deployment, (1 month, 6months, 1 year – deployment accuracy)
- The deployment accuracy/ fixity of the 4D printed material
- The effects of the space environment on deployment, (Radiation, UV, Temperature extremes)
- Activation methods for small or large deployments. (i.e kapton heaters etc)

Other methods to achieve 4D printing have been through chemo-responsive SMPs, by softening swelling or dissolving chemicals. Also photo-responsive SMPs, which can transform when exposed to certain wavelengths of light. Reversible 4D printing with high strength thermoplastics is a significant milestone, which will benefit all industries. To date reversibility has been achieved in liquid crystal elastomers, however this is at high cost and a relatively poor shape memory effect. Other promising work has included laminates of SMP and polyurethane. The design of reversibility requires a thorough understanding of shape memory characteristics and mechanisms of material activation. Others have concentrated on 3D printed polymers that can be activated by multiple stimuli. This is a stepping stone and exactly where the focus for future reversibility should lie, in applying multiple stimuli to a 3D object, to create multi-functionality.

Required education:

Applicants should have completed a University course at Masters Level (or equivalent) in materials science, applied physics, applied chemistry, materials physics/chemistry.

Applicants should have good interpersonal and communication skills and should be able to work in a multi-cultural environment, both independently and as part of a team. Hands-on experience within a laboratory environment is considered an asset.

Applicants must be fluent in English and/or French, the working languages of the Agency. A good proficiency in English is required.

Specific requirements:

- good understanding of materials analysis techniques (microscopic analysis, physical & chemical materials analyses.
- ability to perform experimental work in laboratory
- knowledge of the space environment is an asset

(see instructive slide with embedded video of a 4D printed material deploying.