JOINT MEDIA RELEASE

New packaging plastic that protects as good as aluminium foil

~Tera-Barrier Films invents alternative stretchable plastic for prolonging shelf-life of pharmaceuticals, food and electronics~

1. **06 January 2014** – Tera-Barrier Films (TBF) Pte Ltd, a spin-off company from A*STAR's Institute of Materials Research and Engineering's (IMRE), has invented a new plastic film using a revolutionary nano-inspired process that makes the material thinner but as effective as aluminium foil in keeping air and moisture at bay. The stretchable plastic could be an alternative for prolonging shelf-life of pharmaceuticals, food and electronics, bridging the gap of aluminium foil and transparent oxide films.

2. The new plastic by TBF has one of the lowest moisture vapour transmission rates (*mvtr*), preventing air and moisture from penetrating the layer. The plastic has an air and moisture barrier that is about 10 times better than the transparent oxide barriers which are currently being used to package food and medicines owing to its uniquely encapsulated nanoparticle layer. The film has been validated by a number of companies and potential commercialisation partners.

3. TBF's 700nm encapsulated nanoparticle barrier films - which are thinner than a strand of human hair - have high transparency and are also stretchable, features not possible with aluminium-based packaging material. Inorganic barrier thin films are highly transparent but have lower barrier property and are not stretchable. TBF's films will allow see-through packing and a longer shelf-life for a wide range of products from high-end electronics to perishable goods. Stretchability is another attractive feature in facilitating simple packaging processes.

4. Aluminium as a metal has very high oxygen and moisture barrier properties, but aluminium-based packaging comes at a higher processing cost, is opaque, non-stretchable, and interferes with electronics, making the integration of components like RFID devices difficult. TBF's new stretchable thin films are cost effective and transparent, with barrier properties comparable to that of aluminium foil.

5. "TBF's strategy is to bridge the gap between aluminium foil and transparent oxide films by creating new packaging structures for the niche applications in the food, medical, pharmaceuticals and electronics markets," said Mr Senthil Ramadas, Director & Chief Technology Officer of TBF. "The secret behind TBF's film lies in our patented encapsulated nanoparticle layer that consists of nanoparticles in polymer shells".

6. Conventional multilayer barrier plastics have successive layers of barrier plastic films to enhance the impermeability to air and moisture but they have not achieved higher barrier properties. TBF's film uses minimal layers as its encapsulated nanoparticles increase the packing density of nanoparticles, which in turn makes it extremely difficult for water and oxygen molecules to pass through the film. The encapsulated nanoparticles also actively adsorb and react with water and oxygen molecules to trap them, thus further lowering the amount of moisture and air passing through the film.

7. “The innovation creates a whole new generation of packaging materials that add new and superior functions for use in high value products such as medicine”, says Professor Andy Hor, Executive Director of A*STAR’s IMRE from where the unique barrier film technology was initially developed, incubated and spun-off. “We are glad to see our scientist-entrepreneurs advancing an IMRE-born technology and are looking forward to seeing it make an impact in the market”.

8. “The University of Tokyo confirmed TBF’s barrier film performance at $10^{-6}g/m^2/day$”, said Mr. Nakazawa, Managing Director, KISCO (Asia) Pte. Ltd. “There has been very favourable response from our potential customers in a spectrum of industries wishing to benefit by incorporating TBF’s superior barrier films into their products, these applications range from food and medical packaging to high end PV, lighting and display sectors where TBF’s barrier films excel.”

9. TBF was recently recognised by leading Global Growth consulting firm, Frost & Sullivan as the ‘2013 Global Next Generation Technology Company of the Year in the field of Barrier Films’ due to its novel approach of developing innovative technology for its patented barrier material and barrier stack technology that enhances the performance and reliability of barrier films. TBF has pioneered a unique and innovative technology for developing barrier films, by using nanoparticles to plug the defects in the barrier oxide layer, thereby enhancing barrier effectiveness and at the same time, reducing the number of barrier layers needed.

10. TBF’s reduced number of barrier layers and lower material costs, as compared to conventional barrier film technologies, brings in tremendous cost efficiencies into TBF’s manufacturing process. With TBF’s unique technology and low cost, access to newer applications like Quantum dot color filters, Vacuum Insulated Panels (VIPs), Food & Medical Packaging has been made possible in addition to the conventional application areas like OLED displays or lighting and flexible Solar cells. This opens up a wide spectrum of opportunities for the barrier films market and TBF’s barrier films are well positioned to address the needs from these new and emerging applications.

Encl. **Annex A:** Corporate Profiles
Annex B: About TBF’s new encapsulated nanoparticle layer

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Annex A – Corporate Profiles

About the Tera-Barrier Films Pte Ltd (TBF)

TERA-BARRIER FILMS is jointly founded by Senthil Ramadas and Mark Auch along with Exploit Technologies Pte. Ltd. TBF is a spin-off company from the Institute of Materials Research and Engineering, A*STAR. The strong patent portfolio (56 patents) on transparent gas barrier technology, encapsulation and gas permeation measurement system has been transferred to the company. The technology know-how and expertise could provide a total barrier solution for flexible solar cell and flexible electronics device manufacturers. Tera-Barrier is working in nexus with solar, display and printed electronics customers and has received several product validation reports. For more information, please visit www.tera-barrier.com

About the Institute of Materials Research and Engineering (IMRE)

The Institute of Materials Research and Engineering (IMRE) is a research institute of the Agency for Science, Technology and Research (A*STAR). The Institute has capabilities in materials analysis & characterisation, design & growth, patterning & fabrication, and synthesis & integration. We house a range of state-of-the-art equipment for materials research including development, processing and characterisation. IMRE conducts a wide range of research, which includes novel materials for organic solar cells, photovoltaics, printed electronics, catalysis, bio-mimetics, microfluidics, quantum dots, heterostructures, sustainable materials, atom technology, etc. We collaborate actively with other research institutes, universities, public bodies, and a wide spectrum of industrial companies, both globally and locally. For more information about IMRE, please visit www.imre.a-star.edu.sg.

About KISCO (ASIA) PTE. LTD.

From basic materials to processed products and processing equipment, KISCO (ASIA) PTE. LTD. supplies a full range of products and services related to materials and machineries to such diverse industries as electronics, semiconductors, automobiles, housing, pharmaceuticals and foodstuffs. Along with the latest information and technology, we provide proactive proposals and consulting to support the success of our customer's businesses.
TBF has established a partnership with KISCO Ltd, Japan to commercialise and distribute the barrier films in the Asia Pacific region since 2008.

About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, works in collaboration with clients to leverage visionary innovation that addresses the global challenges and related growth opportunities that will make or break today's market participants. For more than 50 years, we have been developing growth strategies for the global 1000, emerging businesses, the public sector and the investment community. Is your organisation prepared for the next profound wave of industry convergence, disruptive technologies, increasing competitive intensity, Mega Trends, breakthrough best practices, changing customer dynamics and emerging economies? Contact us: Start the discussion

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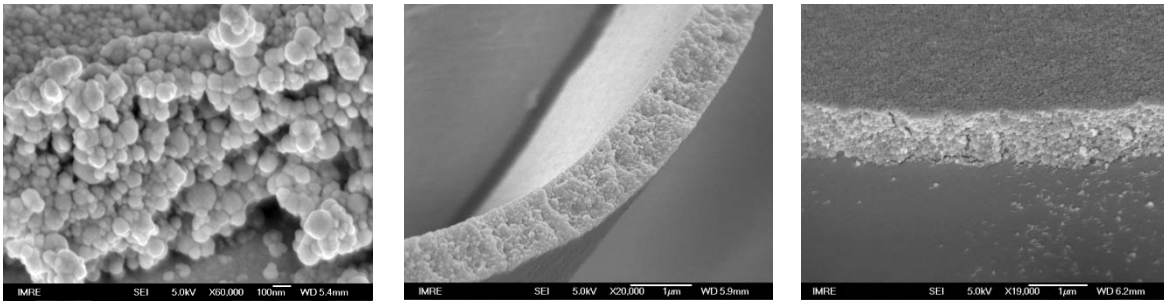
Annex B – About TBF's new encapsulated nanoparticle layer

TBF's Achievement

A patented encapsulated nanoparticle layer coated on to PET has achieved the moisture vapour transmission rate (MVTR) of 5 x 10^{-2}g/m^2.day at 40°C & 100% RH. The moisture barrier performance is 10 times better than transparent oxide barriers, which have been used in food and medical packaging applications. In addition, these 700nm thick encapsulated nanoparticle layers are stretchable and have high transparency. However, most of the inorganic barrier thin films are not stretchable.

Encapsulated Nanoparticles:

The encapsulated nanoparticles layer consists of nanoparticles encapsulated by an organic species via a self-assembly method in which the nanoparticles concentration is very high - up to 70% to 80% by weight. Therefore, the encapsulated nanoparticle layer has high packing density and possesses strong bonding between the particles and the substrate due to the encapsulated organic material. The ratio of nanoparticles to the organic species is critical for the desired transmittance properties. In this concept, the focus is to reduce the thickness of the organic species to the minimum - as low as a few nanometers –which are enough to make the encapsulation partial or complete.



The encapsulated nanoparticles layer (centre and right) consists of nanoparticles encapsulated by an organic species (left) via a self-assembly method in which the nanoparticles concentration is very high - up to 70% to 80% by weight.

Permeation Mechanism:

The encapsulated nanoparticle layer that is coated onto the polymer substrate enhances the barrier properties by two means. Firstly, the high packing density of nanoparticles creates a non-linear path for moisture and oxygen diffusion. The result is a longer path for gas diffusion through the encapsulation material. Next, the encapsulated nanoparticles adsorb and react with the moisture and oxygen to rap the molecules. Therefore, the overall permeation through the encapsulated nanoparticle layer is minimised.

Conventional concepts rely on a barrier layer, which is either completely or substantially devoid of a polymer matrix. The polymer may become porous, thereby leading to a pathway for oxygen and moisture and reducing the lifetime of the packaged devices or perishables. Thus, by reducing or eliminating the polymers in encapsulated nanoparticle layers TBF provides a further advantage in achieving higher barrier performance.

TBF's Competitive Edge:

Aluminium has very low moisture vapour transmission rate (MVTR) and oxygen transmission rate (OTR) properties, but it is higher in cost, opaque, non-stretchable, and interferes with electronics and metal detection, thus making it difficult to integrate systems like RFID devices.

TBF's inorganic oxide barrier coatings are cost effective and transparent, but it has inferior MVTR & OTR properties, compared to the aluminium foil. It is also non-stretchable. TBF's encapsulated nanoparticle layer provides higher gas barrier properties, compared to inorganic

oxide barrier films and an excellent alternate to aluminium foil. However, it has higher transmittance, lower cost and stretchability (over 5%). ***The TBF strategy is to bridge the gap between aluminium foil and transparent oxide films and enables the creation of new packaging structures for niche applications in the food, medical, pharmaceuticals and electronics markets.***

As a marketing partner of TBF, KISCO has taken significant efforts in distributing and validating TBF products in the Asia Pacific region. The new TBF's encapsulated nanoparticle layer (produced by Roll-to-Roll processing) samples were tested and validated by TBF/KISCO's customers and partners. The test results have shown the MVTR properties (by using partner's quadrupole mass spectrometer) of 5 x 10^{-2}g/m^2.day at 40°C & 100% Relative Humidity conditions and the transmittance of 85% (close to PET transmission properties).