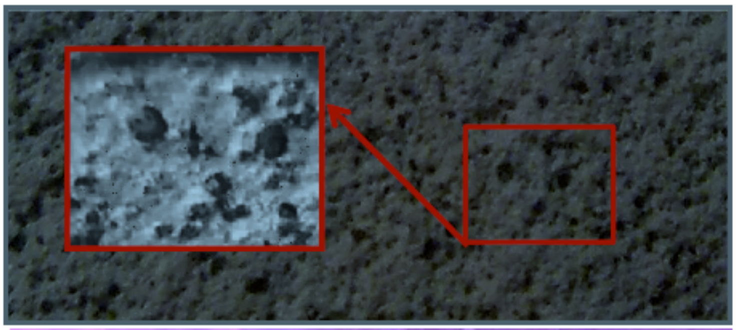
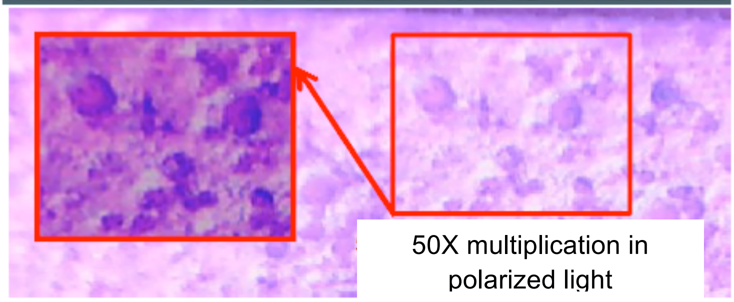
Cured Coating Structure
(After Physical Drying)

ULTRA-THIN THERMAL INSULATION

Long Section of the Material at 12X Magnification





50X multiplication in polarized light

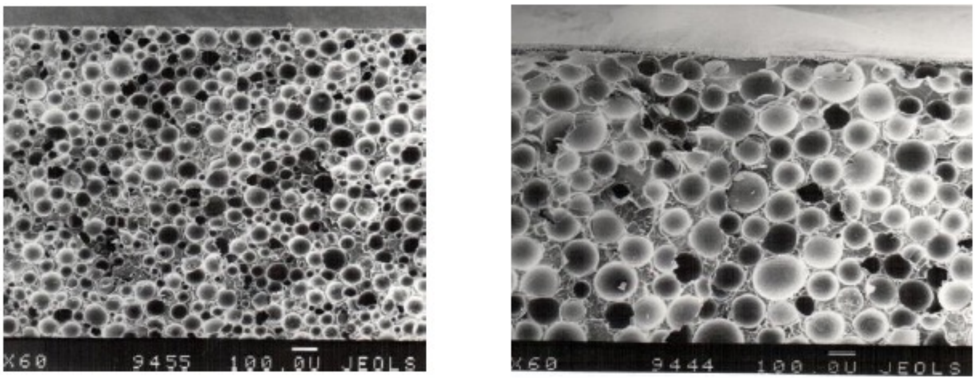
The water content of the coating is 47%. After application, some water evaporates, while the rest facilitates curing process. The black ovals are closed spherical cavities created in the polymer by evaporating water.

The main grey background consists of acrylic copolymers filled, by 85% of their volume, with hollow ceramic evacuated (0.13 Pa) balls dia. 5 to 10 µm.

The coating section reminds of a sponge with millions of ceramic evacuated balls formed around the closed spherical air cavities. The coat shows high elasticity with liner elongation of 67%. Dry coat weight # 0.4 mm = 0.165 kg/m^2.

For each layer, the top part (#60 – 80 µm) has higher density than the middle part and base of the coat. This can be explained as follows.

After the coat is applied, water starts to evaporate from the surface. This process takes 15 to 20 minutes (depending on the ambient temperature and humidity) and falls onto the ‘liquid phase’ of the material, hence air cavities cannot evolve in this thin top coat and it is filled with light ‘popping’ evacuated ceramic balls.



Electron Micrograph: Section of the Top Part

The balls are structured in a combined hexagonal and face-centered arrangement with package density ≈ 0.86 which leads to more efficient blocking of incoming heat flow.

The coat thickness will depend on how soon the impervious surface film appears.

The more slowly the film appears, the thicker the top part will be.

The surface tension distributes the consolidating top coat evenly and creates a smooth dense impervious surface.

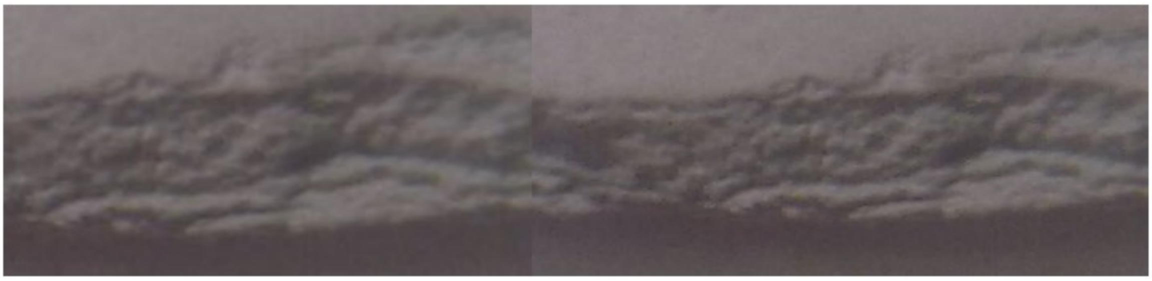
50X multiplication

The remaining water molecules are trapped inside the material between the base (or top edge of the previous coat) and consolidated impervious top film and used to support the material curing process.

The water molecules start to react chemically with bonding components and leave behind closed spherical cavities (dia. 20 to 40 μm) that cannot simply collapse as the liquid phase process is over and the material is under curing.

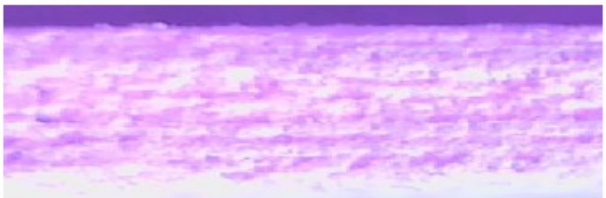
Material Cross-Section at 12X Magnification

The cross-section of each coat shows a *quasi-vacuum structure*: the top part is a thin, 60 to 80 μm-thick, dense impervious film mainly consisting of evacuated microspheres, while the middle part and base are softer, more flexible and contain closed air cavities with the gaps filled with evacuated ceramic microspheres.



Separate coats created by layered application are clearly visible in the cross-section.

50X Magnified Cross-Section in Normal and Polarized Light



Cross-sectional view of the coating reminds of that of a ring-structured tree. For each coat, the top edge is denser than the middle. Thus, by consistent application of the coating, a figurative “layer cake” is made where thin dense boundary films alternate with softer air-filled layers.

The denser surface layer (deep-vacuum layer) is sure to dominate in blocking heat transfer.

The middle part of the coat works somehow differently: when heated, the bonding polymers expand; the air cavities grow in diameter and cause additional evacuation of the middle space.

Thus, heat is secured not only by each top film, but also by middle parts of the coats.

A multiple build-up effect is observed which is natural considering the microscopic composition of the coating and its unique chemical structure.

In addition to the evacuated content of the coats, the material ensures low emissivity due to titanium dioxide additive which dissipates and absorbs IR-electromagnetic waves to avoid over-radiation of heat transfer.

The material also offers
self-contained burn injury prevention
through low **thermal diffusivity (0.0016 m^2/sec)**
and record-braking low heat conductivity (0.001 W/m°C).

2012, Saint Petersburg, Y.V. Bashuyev, Candidate of Engineering, phone: +7(911)778-19-44