Catalytic and photocatalytic nano-membrane

The mainstream application of nano-membrane separation technology for petroleum distillation was shaped several years ago in its current form. Currently nano-membrane separation technology is developing together with catalytic capabilities. In this case the function of a separation nano-membrane is combined with a catalytic cracking function and the resulting material is usually designated as a *catalytic nano-membrane* (CNM). *The major problem standing between academic development of selective separation nanomebrane and its industrial applications (e.g. in petroleum distilleries) consists in contradiction between necessity to use the structure with nano-scale features (pores) and to employ these structures in conditions in which only robust 3D materials can be employed.* For example, it is not clear how to employ the ultra-thin and delicate 1D structure of ALE-derived catalytic nanomembranes in a real petroleum distillery. To address this problem our company proposes to develop nanomembranes with catalytic and photo-catalytic functionality in macroscopic 3D ceramic films, which contain nanopores in vertical channels of this 3D structure. That will enable us to combine high selectivity of nanomembrane with 3D robust structure, which can survive in harsh industrial environment, including vibrations, high temperatures, redox environments etc, typical in petroleum distilleries. We develop a completely new type of nanomembrane, which relies on such structures produced using plasma deposition of ceramic nano-particles. We have developed a way to create 1D nanochannels in these structures. An example of nano-membrane TiO2/YSZ structure with the vertical channels is shown in Figure 1.

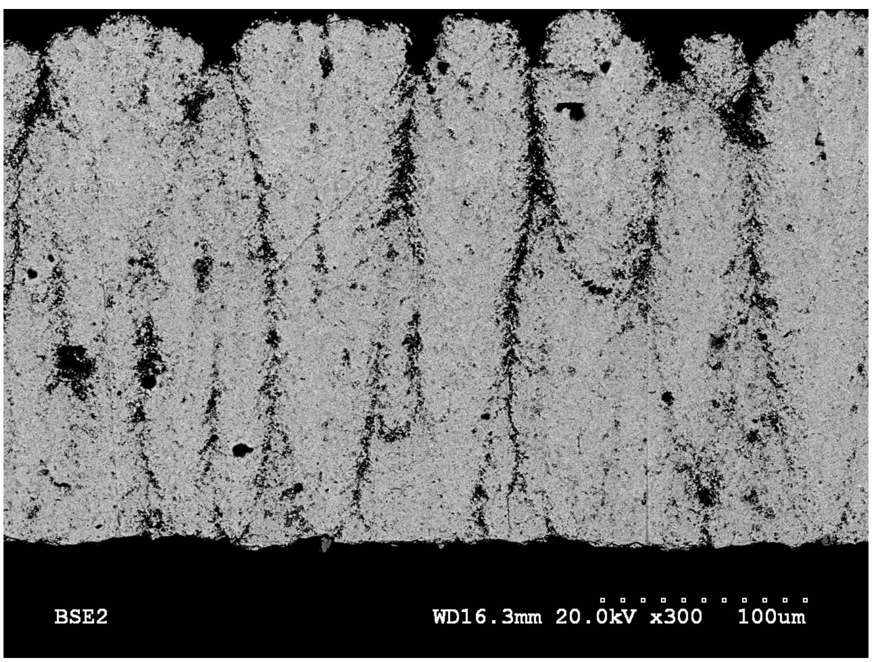

Figure.1 Vertical structure of YSZ membrane

Plasma particle of re-crystallization produces a dendrite structure with variable pore size along the pore length. The diameter of these pores can be tuned in nano-scale. These nanopores were developed in several hundred micron thickness of a TiO_2 film on alumina support. Figure 1 shows that ceramic film is composed on a dendrite like structures, which are shown in Figure 2.

The challenge in producing TiO2/YSZ membranes by plasma spraying is to produce the desired composition and porosity (~40%). YSZ usually requires very high temperature plasma with hydrogen gas in order to melt the powder feedstock. However, plasma gas compositions with even as little as 5% hydrogen gas led to melting of the TiO2. The coatings produced using plasmas with Ar-N2 gas mixtures at short standoff distances tend to have both TiO2 and YSZ particles remaining partially solid during deposition, causing the coating to have much higher levels of porosity, while still containing a sufficient amount of YSZ (Fig. 2). This combination of high open porosity and reasonably high YSZ content is most desirable for ceramic nano-membranes.

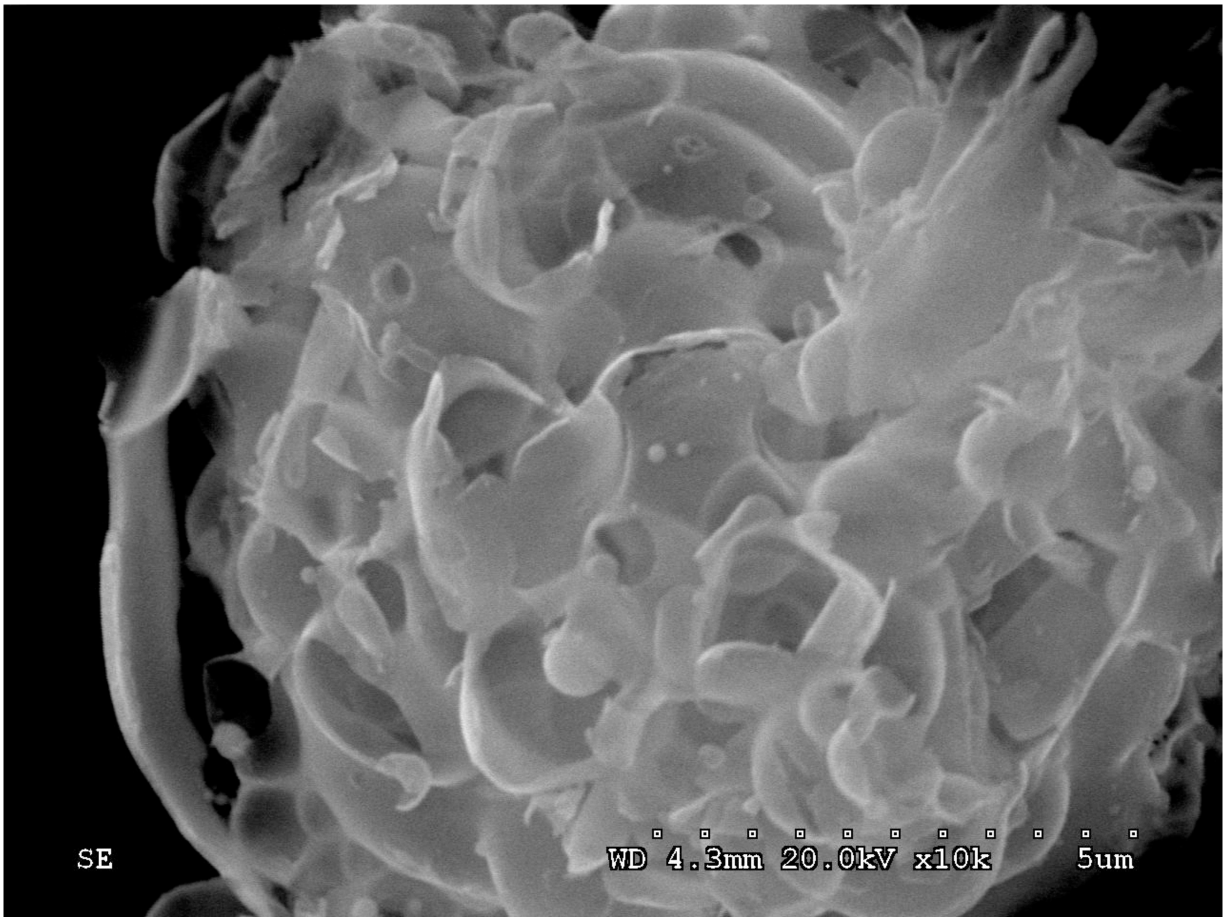

Fig2. Separate porous particle structure.

The interface between these dendrites forms the nano-scale pores, which enables a fraction separation between light and /heavy petroleum fractions.

We have also developed a new class of room temperature photocatalyst for oil cracking, of the polyoxametalite system and we ran an initial feasibility test of this photocatalyst, which shows the cracking of long chains under the light illumination.