IMPROVED IMAGE UNIFORMITY IN LIGHT SOURCES WITH CARBON FIELD EMITTERS

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Recently, large-area carbon-based field emission (FE) cathodes have been demonstrated as viable candidates for vacuum electronics applications such as light sources, LCD backlights and pictorial indicators. Light sources shaped as electric bulbs and CRTs as well as planar lighting elements using carbon-based fibers, films or nanotubes have been successfully introduced. [1-4] Carbon emitters are known to operate with significant emission currents in relatively low vacuum (about 10^{-6} Torr) due to their micro-rough surface. As a result of morphology, the cathodes tend to have long life due to a distribution of the current among a large amount of emission centers; at the same time, emission uniformity is not sufficient to create optimum viewability.

We present here two independent uniformity-enhancing solutions. The first is through the use of a new field-emissive material - reticulated vitreous carbon (RVC)* foam. [5] Up to 97% void volume and high surface area naturally create countless FE centers across the surface. This situation is far superior to PAN carbon fibers or bulk graphite. The bulk RVC can be macro-machined, resulting in sharp cusps at the pore edges acting as emission "tips", as shown in Fig. 1.

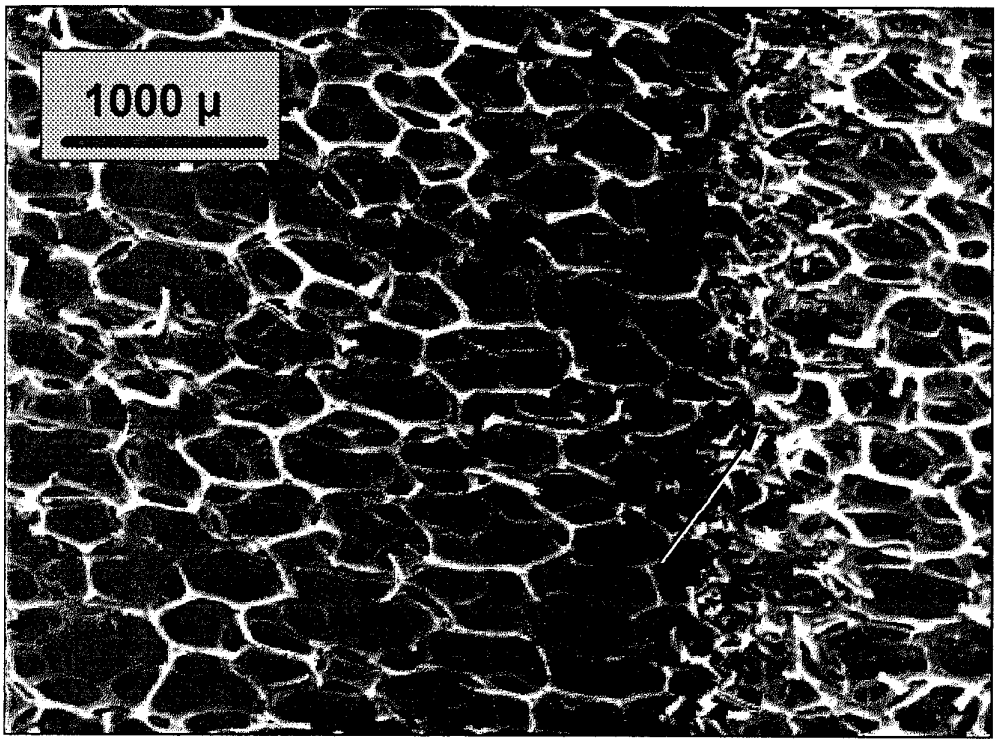

Fig. 1. An SEM micrograph showing the open pore honeycomb structure of the RVC cathode. The arrow points to the vertical wall formed during mechanical cutting.

The selected porosity of the foam determines the total emissive area, and varies emission uniformity across the surface. We present measurements from both focused and unfocused beams from RVC in a wide variety of voltages.

A second uniformity-enhancing solution we present is the use of low-loss external Holographic Light Shaping Diffusers** which enable uniform re-distribution of the scattered light coming from the field emission CL source. The flat diffuser is usually placed outside of the lighting element directly onto the surface of the phosphor screen or at some distance (usually not more than 1-2 cm) away from the surface. As a result of the usage of the light shaping diffusers, the uniformity of the light beam can increase significantly (up to 2-5 times, using standard deviation from average values), while about 85-90% of the light energy is transmitted to the viewer. (Fig. 2)

The combination of these two techniques results in significant improvements in uniformity for light applications.

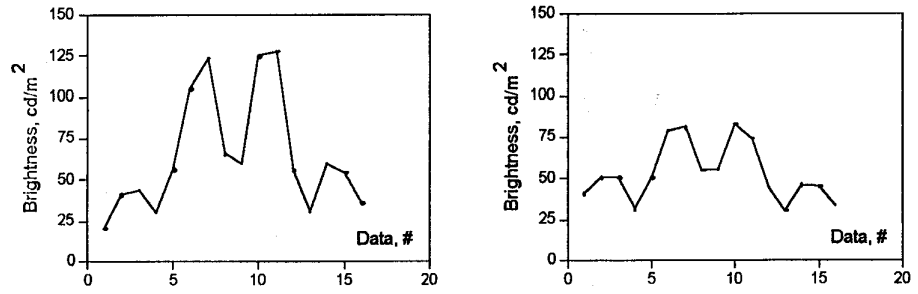

Fig. 2. Improvement in light uniformity (measured as a distribution of brightness across the phosphor screen) resulting from the usage of a Holographic Light Shaping Diffusers. Left: no diffuser, right: 20° angle diffuser.

References

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* Reticulated Vitreous Carbon is a registered trademark of ERG, Energy Research and Generation, Inc., Oakland, CA. A patent covering the application of the RVC material as a field emission source is pending.

** Light Shaping Diffuser or LSD are trademarks of POC, Physical Optics Corporation, Torrance, CA.