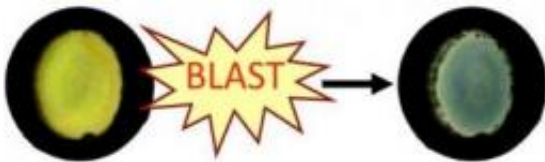


# Color-changing 'blast badge' detects exposure to explosive shock waves

November 29 2010

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Blast exposure disrupts the nanostructure of the blast injury dosimeter, resulting in clear changes in color. The color changes may be calibrated to denote the severity of blast exposure in relation to thresholds for blast-related traumatic brain injury. Credit: Douglas Smith, MD, University of Pennsylvania School of Medicine, *NeuroImage*.

Mimicking the reflective iridescence of a butterfly's wing, investigators at the University of Pennsylvania School of Medicine and School of Engineering and Applied Sciences have developed a color-changing patch that could be worn on soldiers' helmets and uniforms to indicate the strength of exposure to blasts from explosives in the field. Future studies aim to calibrate the color change to the intensity of exposure to provide an immediate read on the potential harm to the brain and the subsequent need for medical intervention. The findings are described in the ahead-of-print online issue of *NeuroImage*.

"We wanted to create a 'blast badge' that would be lightweight, durable, power-free, and perhaps most important, could be easily interpreted, even on the battlefield", says senior author Douglas H. Smith, MD,

director of the Center for Brain Injury and Repair and professor of Neurosurgery at Penn. "Similar to how an opera singer can shatter glass crystal, we chose color-changing crystals that could be designed to break apart when exposed to a blast shockwave, causing a substantial color change."

D. Kacy Cullen, PhD, assistant professor of Neurosurgery, and Shu Yang, PhD, associate professor of Materials Science and Engineering, were co-authors with Smith.

Blast-induced [traumatic brain injury](#) is the "signature wound" of the current wars in Iraq and Afghanistan. However, with no objective information of relative blast exposure, soldiers with brain injury may not receive appropriate medical care and are at risk of being returned to the battlefield too soon.

"Diagnosis of mild traumatic brain injury [TBI] is challenging under most circumstances, as subtle or slowly progressive damage to [brain tissue](#) occurs in a manner undetectable by conventional imaging techniques," notes Cullen. There is also a debate as to whether mild TBI is confused with post-traumatic stress syndrome. "This emphasizes the need for an objective measure of blast exposure to ensure soldiers receive proper care," he says.

### **Sculpted by Lasers**

The badges are comprised of nanoscale structures, in this case pores and columns, whose make-up preferentially reflects certain wavelengths. Lasers sculpt these tiny shapes into a plastic sheet.

Yang's group pioneered this microfabrication of three-dimensional photonic structures using holographic lithography. "We came up the idea of using three-dimensional photonic crystals as a blast injury dosimeter

because of their unique structure-dependent mechanical response and colorful display," she explains. Her lab made the materials and characterized the structures before and after the blast to understand the color-change mechanism.

"It looks like layers of Swiss cheese with columns in between," explains Smith. Although very stable in the presence of heat, cold or physical impact, the nanostructures are selectively altered by blast exposure. The shockwave causes the columns to collapse and the pores to grow larger, thereby changing the material's reflective properties and outward color. The material is designed so that the extent of the color change corresponds with blast intensity.

The blast-sensitive material is added as a thin film on small round badges the size of fill-in-the-blank circles on a multiple-choice test that could be sewn onto a soldier's uniform.

In addition to use as a blast sensor for [brain injury](#), other applications include testing blast protection of structures, vehicles and equipment for military and civilian use.

Provided by University of Pennsylvania School of Medicine

Citation: Color-changing 'blast badge' detects exposure to explosive shock waves (2010, November 29) retrieved 21 April 2023 from <https://medicalxpress.com/news/2010-11-color-changing-blast-badge-exposure-explosive.html>

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