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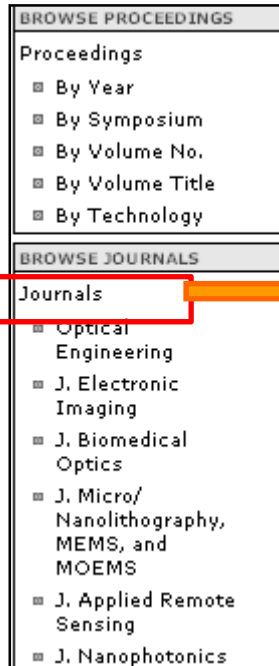
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- Launched in January 2011, the *Journal of Photonics for Energy* (JPE), edited by Zakya Kafafi, focuses on applications of photonics for renewable energy harvesting, conversion, storage, distribution, monitoring, consumption, and efficient usage. JPE articles are freely available through December 2011. Members of SPIE may select JPE as their member-benefit journal or as an additional journal at a low subscription price. If you are not a member, encourage your library to subscribe.
- Chris Mack, adjunct faculty member at the Univ. of Texas at Austin, has been appointed the next Editor-in-Chief of the *Journal of Micro/Nanolithography, MEMS, and MOEMS* (JM3), effective January 2012.

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Peter Goldstein
Philips Color Kinetics, 3 Burlington Woods Drive, Burlington, Massachusetts 01803

This paper describes a process for designing a faceted freeform Fresnel lens. Where a traditional Fresnel lens uses a profile revolved around a central axis, a freeform Fresnel lens uses individual triangular or trapezoidal facets that comprise a freeform surface. This type of lens combines the capability of a freeform surface with the benefits of a Fresnel lens, in particular: thin profile, low cost, small size, and relatively simple geometry calculations. An algorithm is presented to design such a lens that generates an output intensity distribution without depending on symmetry in the light source, the lens aperture, or the output intensity distribution. Two example systems are presented, demonstrating how a freeform Fresnel lens can reshape a beam of light without relying on symmetry.

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Optomechanical design and fabrication of resonant microscanners for a scanning fiber endoscope

Christopher M. Brown¹, Per G. Reinhall², Satoshi Karasawa³, and Eric J. Seibel¹

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Introduction [top](#)

Scanning fiber endoscope (SFE) technology shows promise as a small, inexpensive imaging tool suitable for microendoscopic imaging applications.^{1,2} The distal end of the system consists of a cantilevered single-mode optical fiber actuated at its mechanical resonance. Light projected from the moving optical fiber is focused onto an imaged surface. Light backscattered from the imaged surface is detected pixel by pixel to form an image. Using this method of image acquisition, the resolution of the acquired image is not limited by the number of detectors (optical fibers or CCD elements) in the flexible endoscope. This allows for small size of the image acquisition device, with potentially large fields of view and resolution.

Previous work shows that a microfabrication process can be used to alter the scanning fiber's dynamic and optical properties.² That paper showed that modification of the geometry of a scanning optical fiber through selective etching of the 125- μm cladding diameter surrounding the 4.0- μm mode field diameter of a single-mode optical fiber alters the amplitude of vibration and resonant frequencies of the fiber. That work illustrates how the geometry of the optical fiber influences the dynamics of the scanner, and how the geometry can be modified to improve the imaging properties of the SFE. There are three specific objectives for this work: (1) construct a model that can be used to predict dynamic properties—displacement and resonant frequency—of optical fibers used in a scanning fiber system, (2) develop a fiber microfabrication process that allows us to modify the dynamic properties of an optical fiber without altering its function as an optical waveguide, and (3) use the dynamic model to design geometrically modified fibers that provide improved optomechanical properties.

The modeling efforts presented in this paper are based on Euler-Bernoulli beam theory and linear finite-element analysis (FEA) models of cantilever beams. This numerical method was used to predict the dynamic behavior of the scanning fibers, since the complex geometry of microfabricated fibers prevents closed-form analytic solution. For validation purposes, a model of a cylindrical fiber was

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Abstract. Scanning fiber optical endoscopy shows promise as a small, inexpensive imaging tool. Using this method of image acquisition, a scanning fiber is actuated at mechanical resonance, projecting a light spot across an imaged surface. Light backscattered from scanned spots is measured to form an image. The acquired image field of view, resolvable pixels, and frame rate are dependent on the dynamics of the optical fiber used as a resonant scanner. A finite-element analysis (FEA) model was constructed to predict scanning fiber dynamics, and compared with experimental results. A scanning fiber microfabrication process was developed that allows for the controlled manufacture of fiber scanners. Experimental results confirm that the theoretical model was accurate in predicting the system transfer function with less than 6% error in amplitude and less than 10% error in resonant frequency at the first two resonant modes of a cylindrical and a microfabricated fiber. The scanning fiber microfabrication process proved to be capable of repeatedly etching notches in optical fibers as small as 2.00 ± 0.05 mm in length and 15 ± 2 μ m in diameter. FEA was used to predict the effect of geometry change on microfabricated fiber scan dynamics, yielding candidate designs chosen for enhanced performance of future scanning endoscopes. © 2006 Society of Photo-Optical Instrumentation Engineers. [DOI: 10.1117/1.2188387]

Subject terms: endoscope; optical scanning; resonant scanner; optomechanical design; microfabrication.

Paper 050220 received Mar. 22, 2005; accepted for publication Aug. 17, 2005; published online Apr. 3, 2006.

1 Introduction

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