Specialty optical fiber modeling, fabrication, and characterization: introduction

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In this introduction, we provide an overview of the papers that were accepted for publication in the feature issue on specialty optical fiber modeling, fabrication, and characterization. A total of 22 papers were published in JOSA B. This feature issue presents cutting-edge research on specialty optical fibers and highlights recent developments in a new generation of optical fibers. © 2021 Optica Publishing Group

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The diversity of topics covered by papers in this feature issue demonstrates that specialty fibers (SF) represent an exceptionally versatile tool for optics and photonics research. In particular, SFs are used as a convenient platform for creating novel optical sensors and various photonic devices. Moreover, recent advances in SF fabrication have allowed researchers much freedom to design complex fiber geometries with increasing precision and optical quality. In this issue, we show that the latter advances in fiber fabrication and testing have enabled better control of the nonlinear fiber optical effects toward supercontinuum generation, or the mitigation of such nonlinear effects in fiber lasers, for example. The recent interest toward few-mode fiber and multimode fiber transmission, in part motivated by the potential for spatial-division multiplexing (SDM) communications, has spurred a lot of activity in the study of the complex physical phenomena in such fibers that support a rich diversity of modes and optical interactions. This is exemplified in this issue with articles that study, among other topics, mode coupling at avoided crossings and dispersion engineering in hybrid fibers. Finally, a number of articles investigate novel schemes for the important task of amplifying optical signals in few-mode fibers for next-generation SDM applications.

One of the special sub-topics addresses the application of photonic crystal fibers (PCF) for the development of refractive index optical sensors based on surface plasmon resonance (SPR) and orbital angular momentum (OAM)-excited SPR. Another paper focuses on the detection of the refractive index of bioliquids at THz frequencies in a porous core PCF. The tapering of microfiber was also shown to be useful for monitoring organic materials.

SF represent a highly flexible platform for the development of photonic devices. For example, OAM mode converters based on snake-type fiber resonators and an OAM mode generator with wide spectral tunability based on all-fiber acousto-optic induced long period gratings are successfully demonstrated in this special issue. Besides these devices, broadband polarization beam splitters based on dual-core PCFs and a tunable bidirectional coupler of photons emitted by diamond NV centers with an optical nanowire are also presented. A single-mode-few-mode fiber is also used for the investigation of ultrashort spatiotemporal pulse shaping. An azimuthally asymmetric tubular lattice hollow-core fiber is designed for the development of directional curvature sensors.

Another sub-topic of this special issue is the control of the nonlinear optical effects in SF. One of the papers deals with the mitigation of nonlinear optical effects for scaling the power of fiber lasers in the kilowatt regime using newly designed Yb-doped fibers with heavily doped of P2O5, B2O3, and Al2O3. Highly coherent visible supercontinuum generation in a micrometer-core borosilicate glass PCF is achieved and recent advances in supercontinuum generation in SF are also covered in this special issue. Other complex physical phenomena that occur in SF such as mode coupling and dispersion were also studied. The practical aspects of avoided crossings in solid-core and air-core fibers are analyzed in detail by the authors. Another paper deals with the effect of the influence of beam random angular jitter on few-mode fiber coupling. The same authors also studied the effect of random angular jitter on the F-number of optical fiber coupling systems. One paper demonstrates that all-glass hybrid fibers can combine the properties of
material dispersion, conventional total internal reflection, and anti-resonant fiber design toward dispersion management in SF.

Another important application of SF is in the optical communications industry. Novel designs of few-mode (FM) erbium-doped fibers for the C-band with low differential modal gain and for the optical amplification of 20 OAM modes have been proposed. Furthermore, a new design of a few-mode fiber toward the phase-sensitive amplification of multiplexed signals was also demonstrated by the authors.

Three additional papers discuss the advances in SF fabrication. New approaches of SF preform fabrication and SF drawing based on CO laser heating are described in detail. The authors demonstrate that this method is beneficial to the fabrication of crystalline silicon core preform and silicon core optical fiber manufacturing. One of the papers reports a spun tapering approach on a large mode area double clad ytterbium-doped fiber for high-power pulsed fiber amplification. Perfect output beam quality has been obtained with multi-watt average output power for ps pulse signal amplification.