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Photoinduced Bragg grating formation in optical fibres as a consequence of convective instabilityA. S. Furman, A. F. Ioffe, *Physicotechnical Institute, St. Petersburg, Russia 194021*

Hill and coworkers¹ have discovered that an argon laser beam can produce a Bragg grating in G-doped silica fibre leading to almost total reflection of the pump light. Despite considerable interest to the phenomenon stimulated by possible applications and a large body of studies (see a review²), the nature of the formation of these gratings remains obscure. The stationary models² imply the local response and cannot explain the observed growth of the reflected light. The theory³ based on the non-stationary model shows the growth of the grating. This theory, however, does not take into account the relaxation process leading to saturation of the refractive index and can be valid only for early stages of the grating formation.

We propose here a theory explaining the photoinduced Bragg grating formation in optical fibre as a consequence of convective instability leading to spontaneous growth of temporal fluctuations of local refractive index and intensity of the light. The theory is based on the local model taking into account the relaxation process.

We show that the stationary propagation of the pump light in the fibre is unstable. We emphasize a close analogy between this phenomenon and the photoinduced second harmonic generation in optical fibres which also has been shown to be a result of convective instability.⁴ We interpret the grating formation as amplification of low frequency noise in the pump light. The theory explains and describes strong fluctuations in the reflected light observed during the formation of the gratings. Predictions concerning the dynamics of the grating formation and the resonant enhancement of frequency shifted signal are made which could be checked experimentally.

1. K. O. Hill, Y. Fujii, D. C. Johnson, B. S. Kawaski, *Appl. Phys. Lett.* **32**, 647 (1987).
2. P. St. J. Russel, L. J. Poyutz-Wright, D. P. Hand, *Proc. Soc. Photo-Opt. Instrum. Eng.* **1373**, 126 (1991).
3. V. Mizrahi, S. LaRochelle, G. I. Stegeman, J. E. Sipe, *Phys. Rev. A* **43**, 433 (1991).
4. M. I. Dyakonov, A. S. Furman, *Electron. Lett.* **27**, 1429 (1991); *Opt. Commun.* **91**, 489 (1992).

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Domain structure in corona poled calix[4]arene/polymer films investigated by friction force and Raman microscopyA. G. Vardanyan, O. F. J. Noordman, N. F. van Hulst, J. Greve, *Applied Optics Group, Faculty of Applied Physics, University of Twente, P.O. Box 217, 7500 AE Enschede, The Netherlands*

Newly synthesised organic molecules with strong non-linear optical properties are an important subject of investigation because of their potential use in optical

QTuG56 Fig. 1. Raman spectra of a corona poled calix[4]arene/PPMA film, measured at two different positions. Various PPMA bands are indicated by arrows. The strong band at 1344 cm⁻¹ is due to the calix[4]arene NO₂ vibration.

QTuG56 Fig. 2. Confocal Raman microscopic image of a 309 × 30 μm area of the corona poled calix[4]arene/PPMA film, as measured in the 1344 cm⁻¹ calix[4]arene NO₂ band.

communication, frequency conversion, etc. In this paper Raman spectroscopy, Raman microscopy, and friction force microscopy of corona poled thin films of the organic molecule tetranitro-tetra-(n-propoxy)-calix[4]arene in PPMA are presented.

A calix[4]arene molecule consists of four phenol rings connected by methylene bridges. Functionalization of these rings with four π -conjugated donor-acceptor (D- π -A) systems introduces strong second order non-linear optical properties, as shown by Kelderman et al.¹ We investigated tetranitro-tetra-(n-propoxy)-calix[4]arene in the so-called cone conformation, in which the four phenolic oxygens are all at the same face of the molecule. The cone conformation is of specific interest due to the high degree of organisation of the four D- π -A units, yielding maximal dipole moment (13.8 D) and hyperpolarizability (30·10⁻³⁰ esu), with the dipole moment along the molecular symmetry axis. Thin films of ca-

lix[4]arene oriented by corona poling display a large second order susceptibility (≈ 100 pm/V) as determined via second harmonic generation by Heesink et al.² The orientation has a long term stability over years.² The stability could be explained as caused by the formation of domains, i.e., a phase segregation, during the poling process. In order to understand this phenomenon we have investigated poled calix[4]arene/PPMA films by Raman and friction force microscopy. For Raman microscopy we used a confocal arrangement³ which is tuned to either a calix[4]arene line or a PPMA line, (see Fig. 1). A characteristic Raman image is shown in Fig. 2. For force microscopy we used the friction force mode,⁴ i.e., the lateral movement of the sensing probe, which is sensitive for differences in chemical composition. We have observed a clear phase segregation with domain sizes varying from 50 nm to several microns, depending on the thin film preparation and poling conditions.

1. E. Kelderman, G. J. T. Heesink, L. Derhaeg, Th. Verbiest, P. T. A. Klaase, W. Verboom, J. F. J. Engbersen, N. F. van Hulst, K. Clays, A. Persoons, D. N. Reinhoudt, *Advanced Materials* **5**, 925-930 (1993).
2. G. J. T. Heesink, N. F. van Hulst, B. Bolger, E. Kelderman, J. F. J. Engbersen, W. Verboom, D. N. Reinhoudt, *Appl. Phys. Lett.* **62**, 2015-2017 (1993).
3. J. Greve, G. P. Puppels, "Raman microscopy of single whole cells," in *Biomolecular Spectroscopy*, R. J. H. Clark, R. E. Hester, Eds., vol. 20, (1991), pp. 231-266.
4. R. M. Overney, H.-J. Güntherodt, S. Hild, "Corona treated isotactic polypropylene films investigated by friction force microscopy," *J. Appl. Phys.* **75**, 1401-1404 (1994).

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Nonlinear optics of doped sol-gel derived thin filmsD. L. Williams, D. West,* T. A. King, K. R. Welford,** *Department of Physics and Astronomy, Schuster Laboratory, University of Manchester, Brunswick St., Manchester M13 9PL, U.K.*

Sol-gel optical components have attracted interest due to their low capital and manufacture costs. One advantage of the sol-gel route to optical glasses is that the manufacture of silica and titania is possible at low temperatures, allowing the incorporation of nonlinear dyes. Silica and titania have better heat transport properties than polymers and do not photodegrade. Colloidal silica films are routinely used for antireflection coatings on high power optics because of their high damage thresholds.¹ These films therefore show much promise for nonlinear optical applications where at present high optical intensities are required.

Three different host materials have been used—silica, titania, and organically modified silica. Each requires different preparation methods, exhibits different properties when spin-coated into films, and has a different refractive index as measured by ellipsometry, allowing index control over a wide range.