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ELECTRICALLY STIMULATED LIGHT-INDUCED SECOND-HARMONIC GENERATION IN GLASS: EVIDENCE OF COHERENT PHOTOCONDUCTIVITY

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Abstract

A strong electrostatic field applied to glass is spatially modulated by intense light at frequencies ω and 2ω. The phenomenon is explained in terms of photoconductivity being dependent on the relative phase of the light fields at different frequencies.

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Summary

Interference between different quantum processes opens a prospect of a new degree of freedom in the control of physical processes - not only by the intensity or the polarization of light. but also by the phase of light [1,2]. SHG via photoinduced spatially-oscillating electrostatic fields in glass was probably the first observed phenomenon where photocurrent due to interference between the one- and two-photon transition moments was involved [3-5]. However. modulation of the total cross-section of ionizing transitions due to quantum interference (coherent photoconductivity) has been observed only in atomic systems [6]. Here we report the first to our knowledge experimental evidence of coherent photoconductivity in solid state materials - observation of *efficient* second-harmonic generation in glass subjected to a strong external electrostatic field.

The orthogonality of the wave-functions in the excited state of the one- and two-photon transitions in centosymmetric media leads to the absence of coherent photoconductivity in glass. However, in the presence of a strong dc field (breaking inversion symmetry of glass) the wave-functions in the excited state of one- and two-photon transitions are not orthogonal any more. This produces modulation of the total ionizing cross section and hence a corresponding modulation of the photoconductivity. A spatially oscillating ohmic current induced by the applied field leads to a periodic screening of this field and appearance of QPM grating.

In our experiments we used Ge-doped fibres with built-in capillaries on both sides of the core, suitable for introducing wire electrodes. A mode-locked and Q-switched Nd-YAG laser was used as pump source. When an electric field ($\sim 5 \times 10^6$ V/cm) was applied we observed strong increase of the SH signal followed by a gradual decay, together with the "echo" signal due to the recovery of the internal electric field (reduced to zero via ohmic conductivity) after switching off the voltage (Fig.1). The SH signal and the half-growth time increased and decreased respectively with the applied voltage (Fig.2). We achieved conversion efficiencies as high as 2% for peak powers of 1 kW, which is ~ 10 times higher than in the experiments without electric field applied (Fig.3). We estimated the amplitude of $\chi^{(2)} \simeq 10^{-14}$ m/V (which may be a record in the experiments on self-induced SHG in fibres), which corresponds to a modulation of $\sim 8\%$ in the applied field. Our experimental results are in excellent agreement with the mechanism based on photoconductivity being dependent on the relative phase between light fields at frequencies 2ω and ω.

References

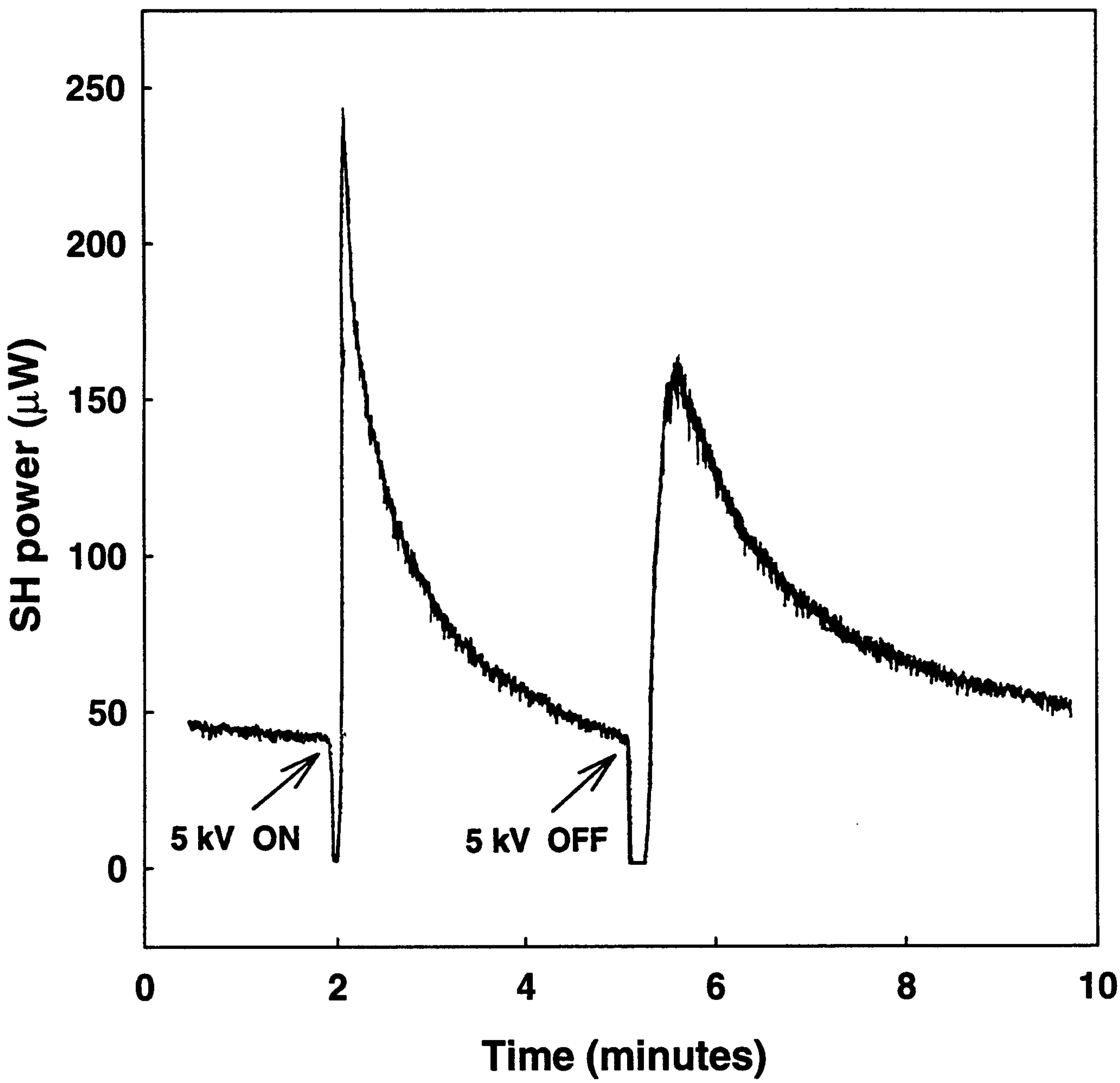
1. E. Dupont, P. B. Corkum, H. C. Liu, M. Buchanan, and Z. R. Wasilevski, Phys. Rev. Lett. **74**, 3596 (1995).
2. R. J. Glauber, in *Quantum Optics* edited by R. J. Glauber, Proceedings of the E. Fermi International School in Physics, Vol. 62 (New York - London: Acad. Press, 1969).
3. U. Osterberg and W. Margulis, Opt. Lett. **11**, 516 (1986).
4. R. H. Stolen and H. W. K. Tom, Opt. Lett. **12**, 585 (1987).
5. E. M. Dianov, P. G. Kazansky, and D. Yu. Stepanov, Sov. J. Quantum Electron. **19**, 575 (1989).
6. Y. Y. Yin, C. Chen, D. S. Elliot, and A. V. Smith, Phys. Rev. Lett. **64**, 2353 (1992).

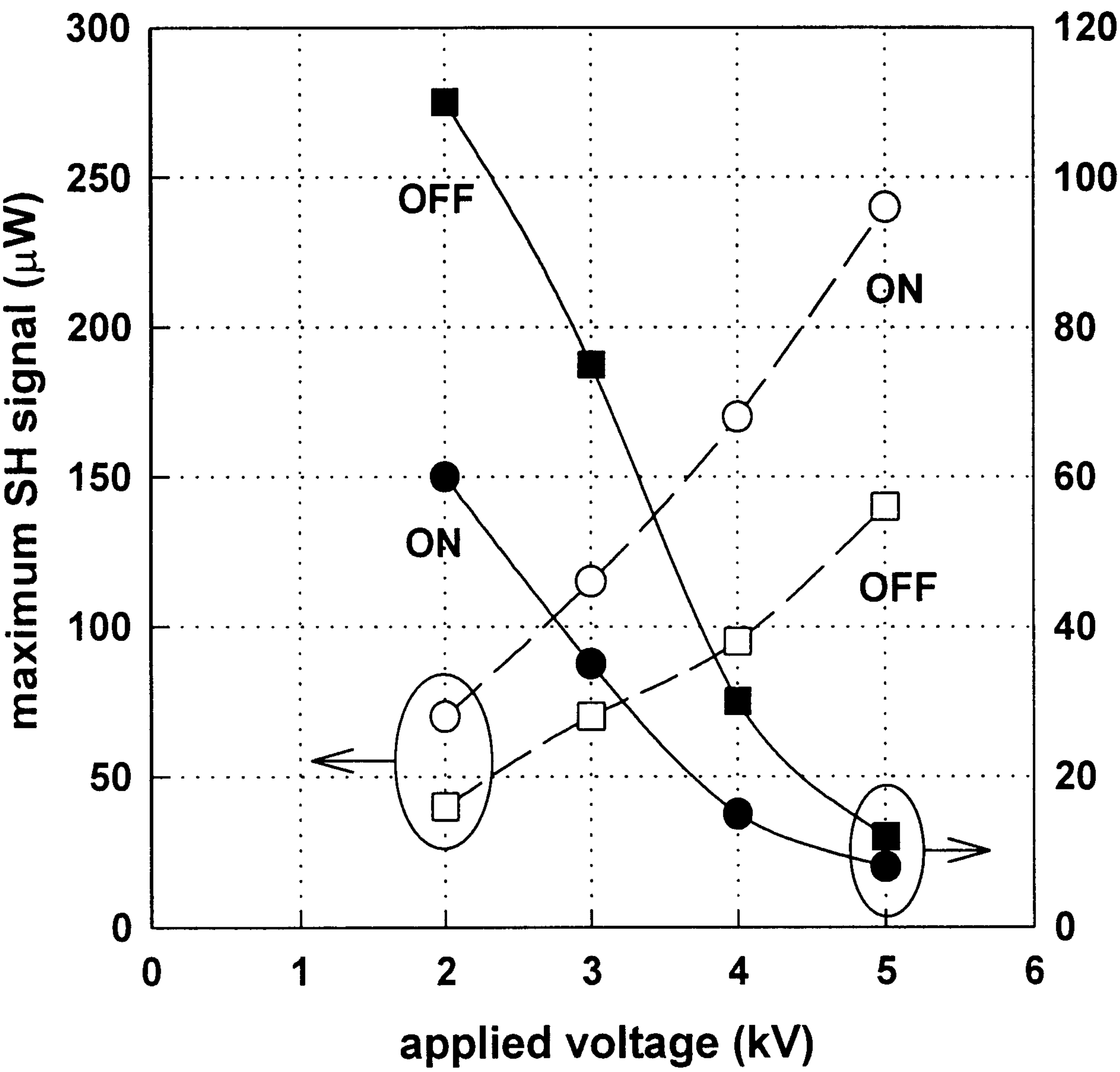
Figure Captions

1. Time dependence of SH signal in a fibre when a voltage of 5 kV was repeatedly switched on and off. The length of the fibre is ~25 cm, the superposition of the electrodes is ~20 cm and the distance between electrodes is ~9 μm. Average pump power is ~12 mW.

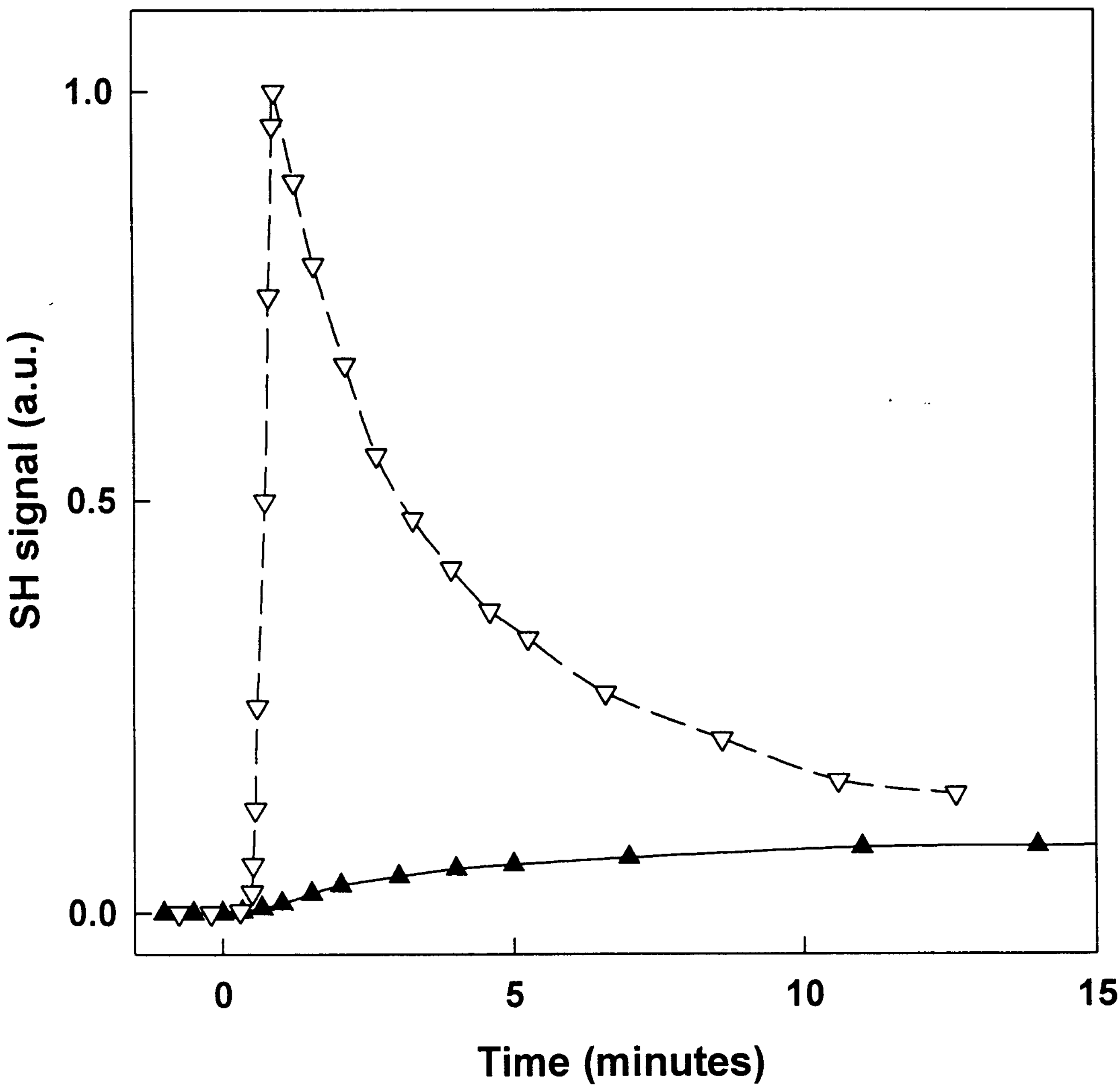
2. Dependencies of the maximum SH signal and time necessary to reach half of this signal on applied voltage when the voltage is switched ON and OFF respectively.

3. Time dependence of SH signal in a fibre with external SH seeding of ~40 μW average power (opened triangles). The seeding was launched at t=0. The SH growth was monitored by blocking the SH seeding. Time dependence of SH signal in a fibre with applied voltage of 5 kV (filled triangles). The voltage was switched on at t=0.


250
200
150
100
50
0
SH power (μW)
5 kV ON
5 kV OFF
0
2
4
6
8
10
Time (minutes)



300
250
200
150
100
50
0
120
100
80
60
40
20
0
OFF
ON
ON
OFF
0
1
2
3
4
5
6
maximum SH signal (μW)
half growth time (s)
applied voltage (kV)



1.0
0.5
0.0
SH signal (a.u.)
0
5
10
15
Time (minutes)