

Zeitschrift: Helvetica Physica Acta
Band: 62 (1989)
Heft: 6-7

Artikel: Fabrication of high-speed GaAs photodiodes with transparent inium tin oxide (ITO) Schottky gate
Autor: Mittelholzer, M. / Loepfe, R. / Schaelin, A.
DOI: <https://doi.org/10.5169/seals-116138>

Nutzungsbedingungen

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. [Mehr erfahren](#)

Conditions d'utilisation

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. [En savoir plus](#)

Terms of use

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. [Find out more](#)

Download PDF: 22.02.2026

ETH-Bibliothek Zürich, E-Periodica, <https://www.e-periodica.ch>

FABRICATION OF HIGH-SPEED GaAs PHOTODIODES WITH TRANSPARENT INDIUM TIN OXIDE (ITO) SCHOTTKY GATE

M. Mittelholzer, R. Loepfe, A. Schaelin and H. Melchior

Institute of Quantum Electronics, ETH Hoenggerberg, CH-8093 Zurich

Abstract: High-speed (FWHM 20 ps) GaAs photodiodes have been fabricated using transparent indium tin oxide (ITO) Schottky gates. The use of ITO results in responsivities of 0.30 A/W (external quantum efficiencies of 45%) at 830 nm. The photodiode's intrinsic response speed has been determined by nonlinear autocorrelation measurements.

1. Introduction

With photodiodes based on semitransparent metal Schottky gates it is difficult to achieve high responsivities due to the often poor transmittance of the metal layer. A better solution uses transparent contacts such as indium tin oxide (ITO) as a highly transparent Schottky gate.

Thin films of ITO have found wide-ranging applications in numerous opto-electronic devices [1], recently, in high sensitivity photodiodes [2].

2. Device Fabrication and Characteristics

The ITO/GaAs mesa photodiodes (Figure 1) consist of a $0.6 \pm 0.1 \mu\text{m}$ thick n^- absorbing layer ($N_D = 2 \cdot 10^{16} \text{ cm}^{-3}$) over an underlying $2 \mu\text{m}$ thick n^+ buffer and contact layer ($N_D = 3 \cdot 10^{18} \text{ cm}^{-3}$). In order to minimize parasitic capacitance the GaAs material is grown by liquid phase epitaxy (LPE) on a semi-insulating substrate. The transparent electroconductive ITO layer (Schottky gate) is deposited by reactive rf ion-beam sputtering. Since the refractive index of ITO is ~ 2 [1], the 1000 \AA thick ITO layer acts as an ideal antireflection coating to GaAs at 830 nm.

Five photolithographic process steps were necessary to fabricate the mesa structures. Typical diode areas were $250 \mu\text{m}^2$. The GaAs-chips were incorporated into coplanar waveguides and flip-chip mounted onto a sapphire substrate, which allows broadband electrical transmission [3].

The electrical diode characteristics show excellent rectifying action with a forward bias turn-on voltage of approximately 0.5 V and a reverse-bias breakdown voltage of 23 V. The leakage current is less than 1 nA at 10 V reverse bias. At 830 nm the photodiodes exhibit responsivities of 0.30 A/W at -12 V bias. This responsivity is limited by the depleted width of the active n^- -GaAs layer.

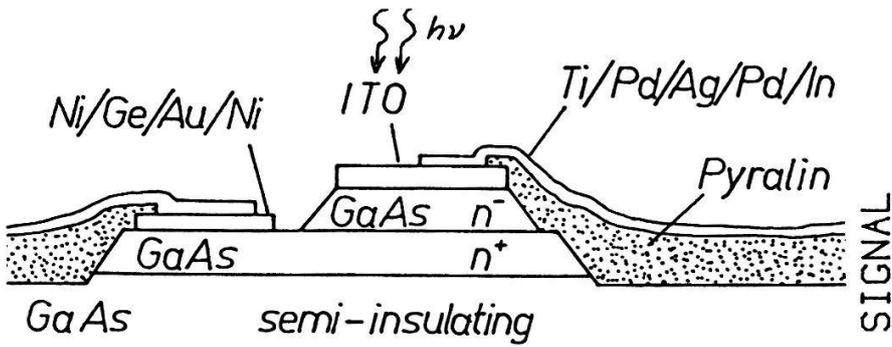


Figure 1: Schematic section through the device.

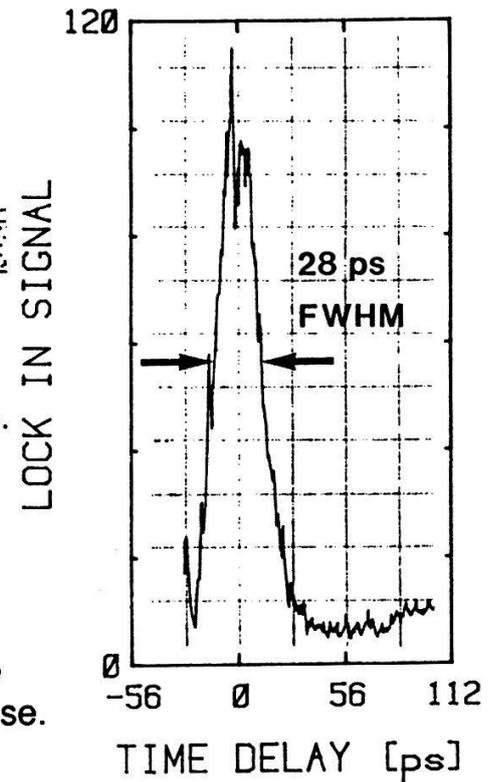


Figure 2: Autocorrelation signal of the photodiode's impulse response.

3. Nonlinear Autocorrelation Measurements

A beam of 4 ps optical pulses at a wavelength of 583 nm is split in two, and one beam is delayed a variable time τ with respect to the other. The two beams are chopped at different frequencies f_1 and f_2 and are focused to overlapping spots onto the photodiode. Signal components at the sum $f_1 + f_2$ of the chopping frequencies are detected using a lock-in amplifier. Such measurements yield directly the autocorrelation function of the temporal response of the device [4, 5].

Figure 2 shows the nonlinear response of the photodiode as a function of the relative delay time τ between the optical pulses. Assuming Gaussian pulses, deconvolution of the photodiode's autocorrelation signal (FWHM 28 ps) leads to an intrinsic response of FWHM 20 ps, which corresponds to a -3 dB bandwidth of 24 GHz. The appeal of this method is that the only high-speed part of the experimental system need to be the optical pulses themselves.

References

- [1] K. L. Chopra, S. Major and D. K. Pandya, Thin Solid Films 102, 1 (1983)
- [2] D. G. Parker, Electron. Lett. 21, 778 (1985)
- [3] P. Schmid and H. Melchior, Rev. Sci. Instrum. 55 (11), 1854 (1984)
- [4] T. F. Carruthers and J. F. Weller, Appl. Phys. Lett. 48 (7), 460 (1986)
- [5] R. Loepfe, A. Schaelin, H. Melchior and M. Blaser, H. Jaeckel and G. L. Bona, Appl. Phys. Lett. 52 (25), 2130 (1988)