



HAL
open science

Enhanced Resonant Raman scattering of GaN functional layers using Al thin films -a versatile tool for multilayer structure analysis

Alina Muravitskaya, Anna Rumyantseva, Atse Julien Eric N'dohi, Camille Sonneville, Dominique Planson, Pierre-Michel Adam, Sylvain Potiron, Mihai Lazar

► To cite this version:

Alina Muravitskaya, Anna Rumyantseva, Atse Julien Eric N'dohi, Camille Sonneville, Dominique Planson, et al.. Enhanced Resonant Raman scattering of GaN functional layers using Al thin films -a versatile tool for multilayer structure analysis. ECSCRM2020-2021, Oct 2021, Tours, France. hal-03410757

HAL Id: hal-03410757

<https://hal.science/hal-03410757>

Submitted on 1 Nov 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Enhanced Resonant Raman scattering of GaN functional layers using Al thin films - a versatile tool for multilayer structure analysis

A. Muravitskaya^{1,2}, A. Rumyantseva¹, A.J.E. Ndohi³, C. Sonnevile³, D. Planson³,
P.M. Adam¹, S. Potiron², M. Lazar^{1,2*}

¹ Laboratory Light, Nanomaterials & Nanotechnologies, CNRS ERL 7004, University of Technology of Troyes, 12 rue Marie Curie, 10004 Troyes, France

² Laboratoire de Recherche en Nanosciences, Université de Reims Champagne Ardenne, Moulin de la Housse, 51687 Reims, France

³ AMPERE, UMR 5005 CNRS, INSA Lyon, Villeurbanne, F-69621, France

*E-mail: mihai.lazar@utt.fr (corresponding author)

The resonant Raman scattering is a well-established method for analyzing the surface properties of the GaN determining the crystalline quality, the stress, doping, free carrier concentration for process and growth monitoring [1]. In GaN power devices one needs to selectively analyze thin layers in surface (active layers as emitters, channels, junction termination extensions created by ion implantation, metal-contact interfaces) with thickness does not exceed micrometer at most and can go to ~100 nm and even less. To gain the correct values, the influence of under-layers present in the vertical device (hetero)structure (substrate, buffer, drift layers, etc.) should be eliminated. Thus, for GaN thin layer analyses, UV excitation is preferred to the classical visible or IR excitation wavelengths, since it allows to examine a surface layer of about 40 nm thick (under 325 nm excitation) [2]. However, as GaN has a direct bandgap, strong photoluminescence (PL) contribution can interfere in the measurements and decrease quality and resolution of the obtained Raman spectra. One of the approaches to decrease the PL background and increase the Raman signal is to place plasmonic nanoparticles on the top of layer of interest, that results in a quenching of the PL due to the high non-radiative transfer of the excitation energy to metal and in the same time Raman scattering benefits from the local field enhancement and increase in radiative decay rates near resonant plasmonic nanoparticles. In this work we propose to use structured Al films to diminish the influence of the PL on the resonant Raman spectra of GaN and to increase its overall resolution.

GaN thin epilayers from CNRS-CRHEA with a doping concentration ranging from 10^{16} to 10^{17} cm^{-3} were covered with Al nanoparticles and Al thin films, which were deposited by means of the vacuum evaporation technique (e-beam PlassysMU400). The Al nanoparticles film was obtained for a thickness of the deposition of 6 nm (inset Fig.1). The Al thin film was obtained after 20 nm deposition. In both cases samples were heated up to 400°C during the deposition. The Al film had a reflection which confirms the formation of the rough continuous film, while Al nanoparticles film was non-reflecting. The PL and μ Raman measurements were done under $\lambda_{\text{ex}}=325$ nm in back-scattering geometry (LabRAM spectrometer of Horiba Scientific).

The deposition of the Al on top of the GaN resulted in a drastic fall of the photoluminescence intensity (Fig.1a). In the case of the Al nanoparticles film the PL has decreased 10 times, while for the Al thin film it has decreased 100 times. Then we observed the revealing of the Raman modes in the spectra (Fig.1b): $732 \text{ cm}^{-1} - A_1(\text{LO})$, $568 \text{ cm}^{-1} - E_2^{\text{high}}$ and $140 \text{ cm}^{-1} - E_2^{\text{low}}$, which are allowed in GaN layers in the backscattering configuration [3]. Important to note that we do not observe the contribution of the sapphire (GaN epilayer substrate in our samples) modes, which often change the shape of the spectrum of GaN. The Raman lines are more pronounced in the case of the Al thin film, than for the Al nanoparticles film, but for the latter one the lines are sharper. For both films the absorption of the GaN emission by Al layers and consequent fall of the PL play an important role in the Raman lines appearing. Also, the plasmonic enhancement of the Raman scattering may occur, especially as Al sustains localized surface plasmon resonances in the UV region [4].

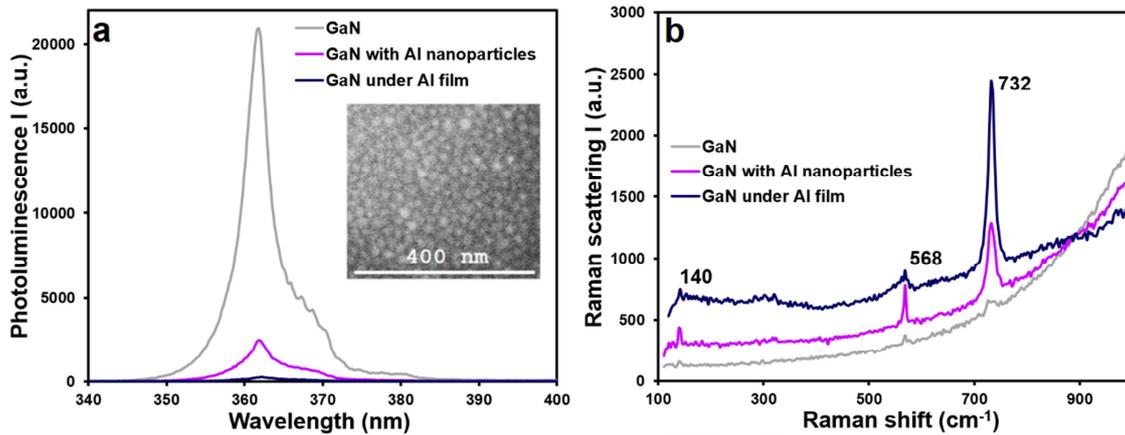


Fig. 1. Photoluminescence (a) and Raman scattering spectra (b) ($\lambda_{\text{ex}}=325$ nm) of the GaN epilayers covered with layer of Al nanoparticles and covered with thin Al layer. In the inset: scanning electron microscopy of the Al nanoparticles.

4H-SiC epilayers and substrates have been also tested without and with Al layer deposited during the same run with the GaN samples. Even though the PL signal was reduced 10 times (Fig. 2a) the enhancement of the Raman scattering was not observed (Fig. 2b). We note that SiC compared to GaN has an indirect bandgap, then the PL signal is not so high. In the PL spectrum one can even see the Raman scattering contribution around 330 nm (Fig.2a). Therefore, doping check or other stress and defects identification could be done by direct UV Raman measurements without Al nanoparticles or nanolayers on the surface.

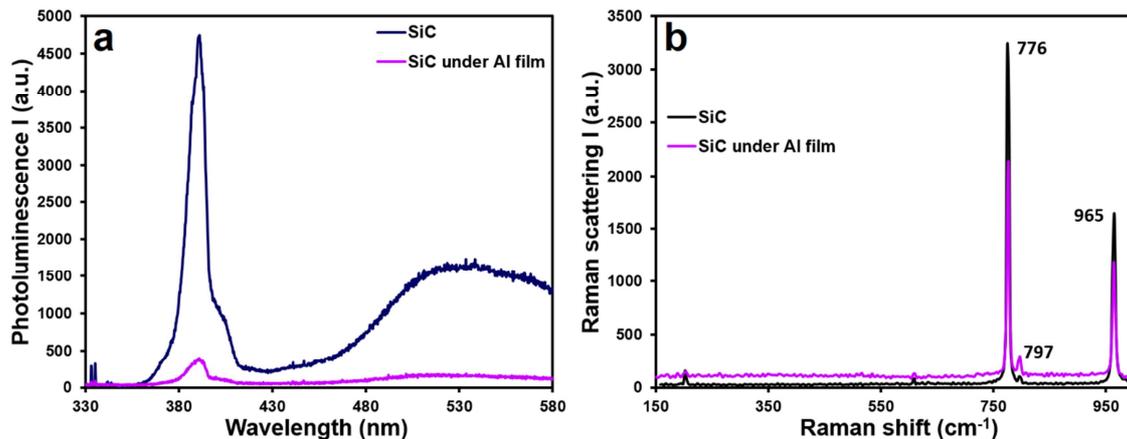


Fig. 2. Photoluminescence (a) and Raman scattering spectra (b) ($\lambda_{\text{ex}}=325$ nm) of the SiC epilayers covered with thin Al film.

Thereby we show that Al thin layers may improve the quality and intensity of the resonant UV excited Raman scattering of the GaN functional layers and therefore provide a doping control for the power devices.

- [1] M. Kuball, *Surface and Interface Analysis*. 31, 19, 987-999 (2001).
- [2] J.F. Muth, J.H. Lee, I.K. Shmagin, R.M. Kolbas, H. C. Casey Jr., B. P. Keller, U. K. Mishra, S.P. DenBaars, *Appl. Phys. Lett.* 71, 18, 2572 (1997).
- [3] Z. C. Feng, W. Wang, S. J. Chua, P. X. Zhang, K. P.J. Williams, G. D. Pitt, *JRS*. 32, 10, 840-846 (2001).
- [4] M. W. Knight, N. S. King, L. Liu, H. O. Everitt, P. Nordlander, N. J. Halas, *ACS Nano*. 8, 834-840 (2013).