



Molecular beam epitaxy of TaSe₂ on GaP(111)B

C. Sthioul, H. Koussir, Y. Chernukha, N. Chapuis, E. Haber, Pascal Roussel,
Christophe Coinon, Pascale Diener, B. Grandidier, Xavier Wallart

► To cite this version:

C. Sthioul, H. Koussir, Y. Chernukha, N. Chapuis, E. Haber, et al.. Molecular beam epitaxy of TaSe₂ on GaP(111)B. Colloque du GDR/GDR-I HOWDI, May 2023, Porquerolles, France. . hal-04118157

HAL Id: hal-04118157

<https://hal.science/hal-04118157>

Submitted on 28 Jul 2023

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.

Molecular Beam Epitaxy of TaSe₂ on GaP(111)B

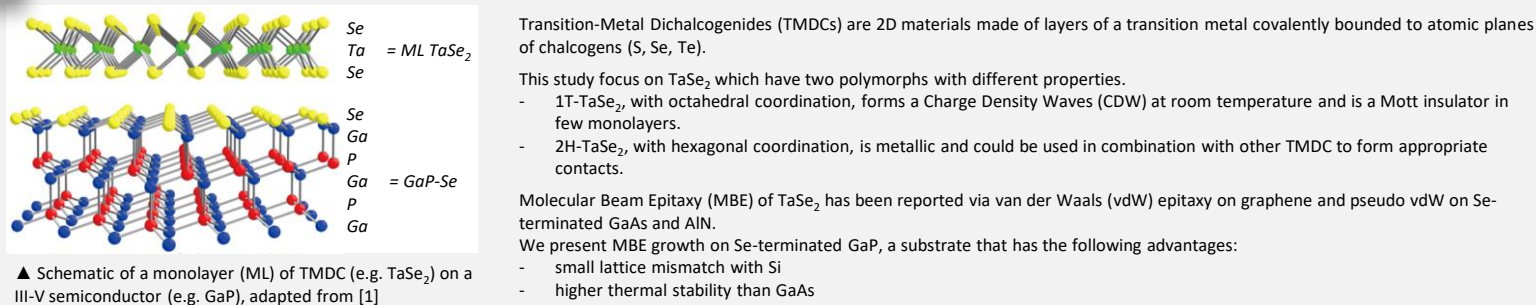
C. Sthioul^{1†}, H. Koussir¹, Y. Chernukha¹, N. Chapuis¹, E. Haber¹, P. Roussel², C. Coinon¹, P. Diener¹, B. Grandidier¹, and X. Wallart¹

¹Univ. Lille, CNRS, Centrale Lille, Univ. Polytechnique Hauts-de-France, Junia-ISEN, UMR 8520 – IEMN, F-59000 Lille, FRANCE

²Unité de Catalyse et de Chimie du Solide (UCCS), Université de Lille, CNRS, Centrale Lille, ENSCL, Université d'Artois, UMR 8181 – UCCS, F-59000 Lille, FRANCE

[†]corentin.sthioul@univ-lille.fr

Context and goal



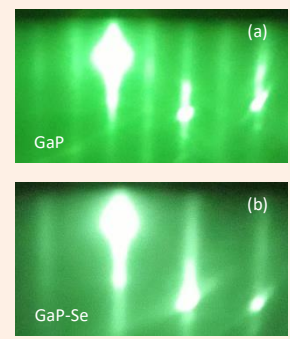
[1] A. Ohtake et al., "Evolution of surface and interface structures in molecular-beam epitaxy of MoSe₂ on GaAs (111) A and (111) B", *Crystal Growth & Design* 17.1 (2017), pp. 363–367

Influence of growth conditions

Sample preparation

Preparation of GaP(111)B-Se:

- GaP(111)B substrates are deoxidized under PH₃ and atomic H in a III-V MBE reactor and exhibit a 2x2 reconstruction
- GaP-Se terminated are prepared under a Se flux in the 10⁻⁴ Torr range from 250°C to 450°C in a TMDC reactor

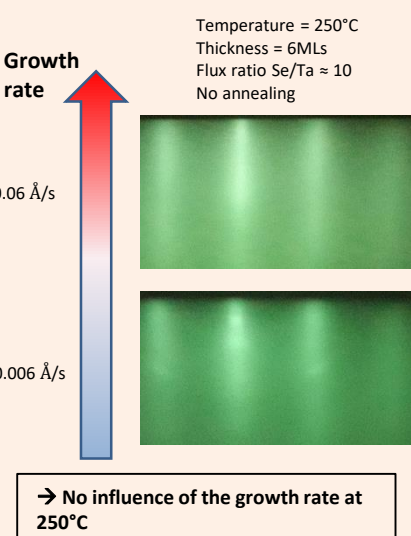


TaSe₂ growth:

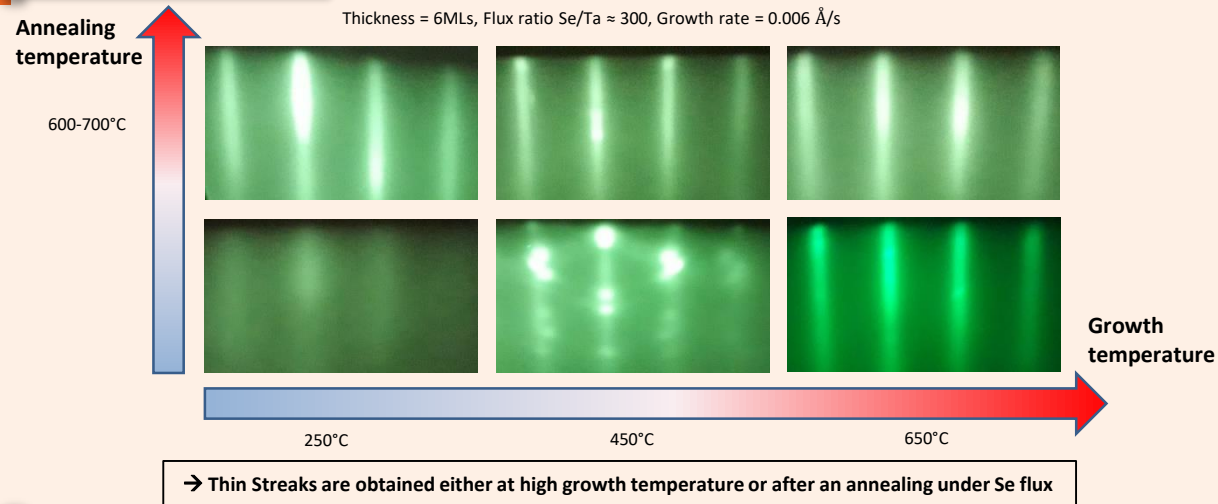
- Growth temperature from 250 to 650°C
- Typical Ta growth rate between 0.001 and 0.02 Å/s
- Se flux ranging from 10⁻⁷ to 10⁻⁵ Torr
- Annealing under Se flux up to 750°C

Se capping layer (30-50 nm) for ex-situ characterizations (XRD, STM)

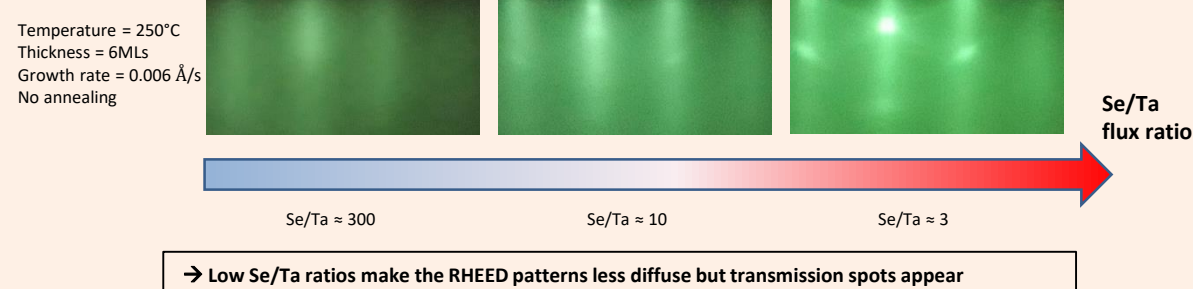
Growth rate



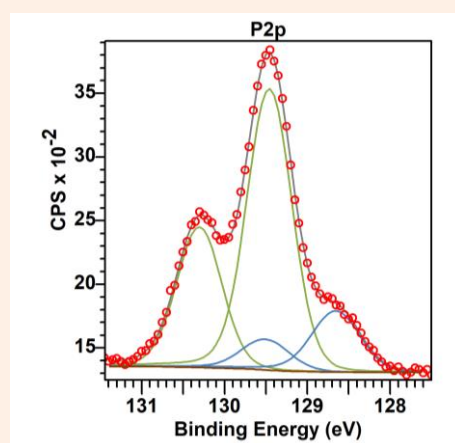
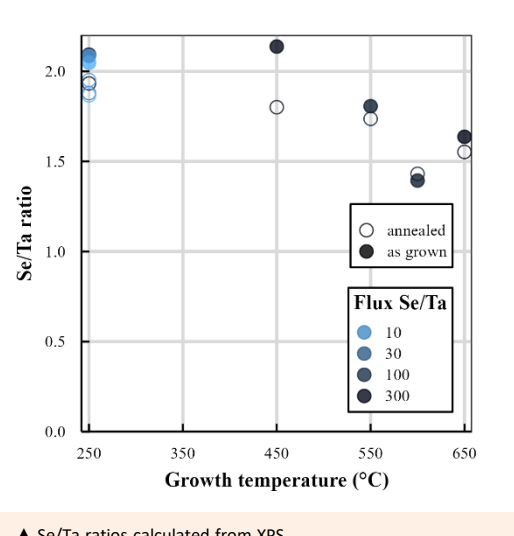
Temperature



Se/Ta flux ratio

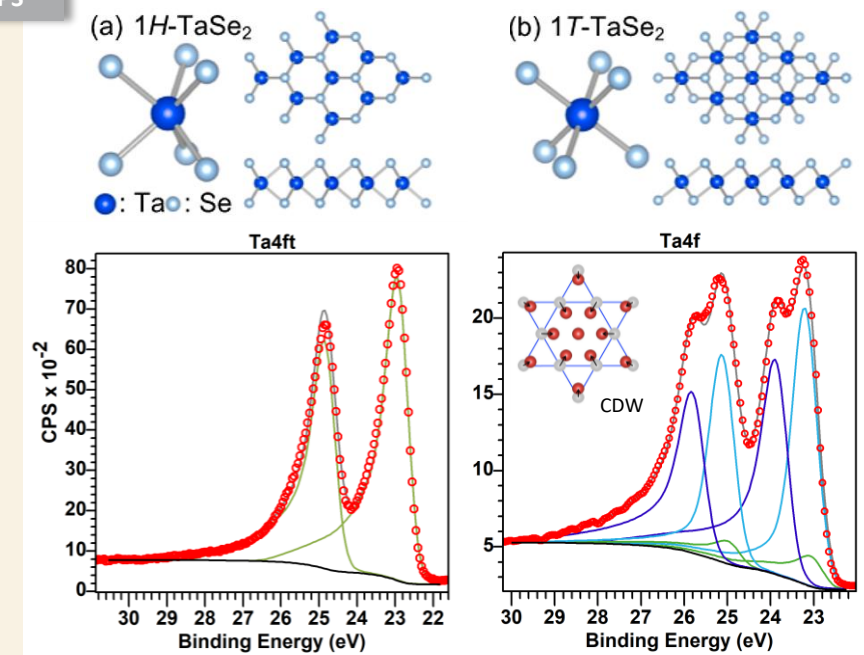


High temperature degradations

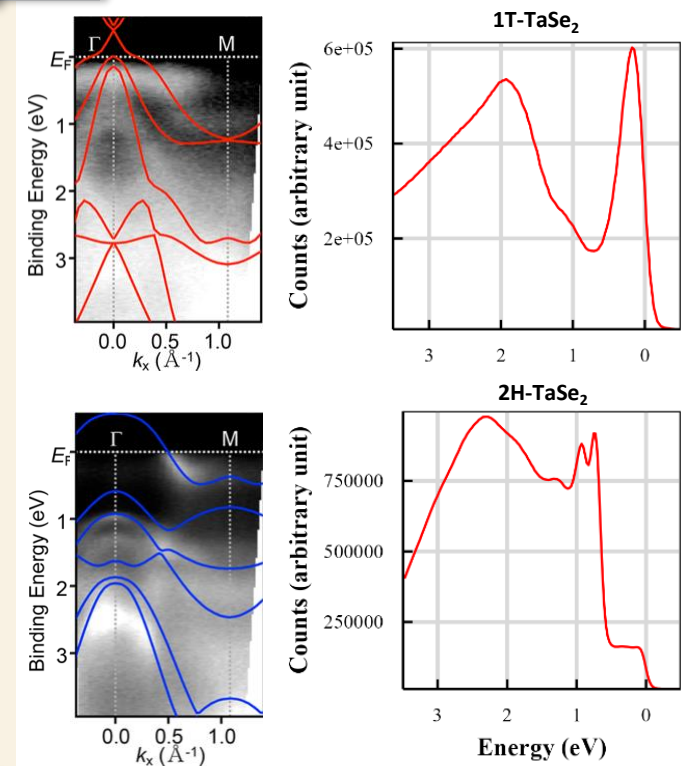


Phase determination

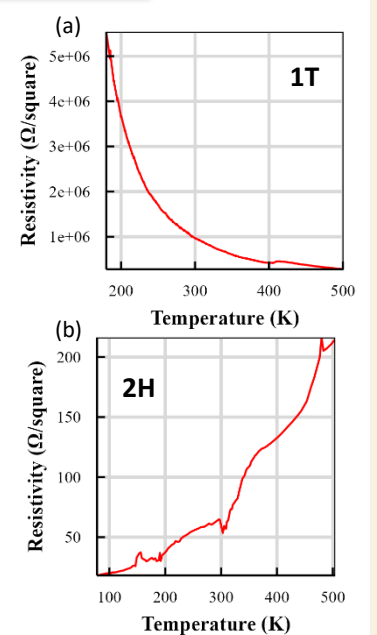
XPS



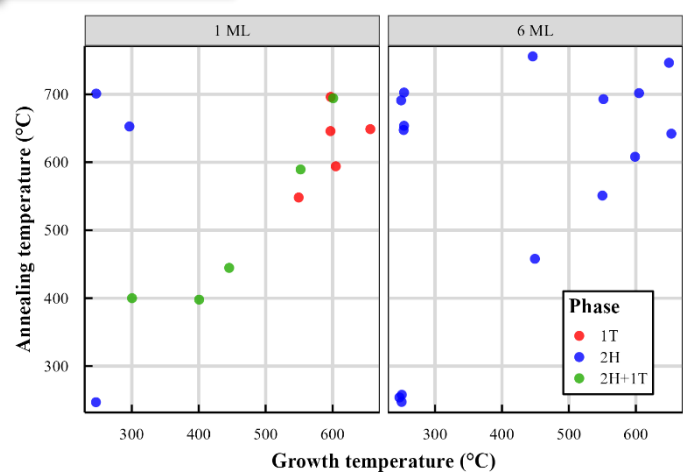
UPS



Resistivity

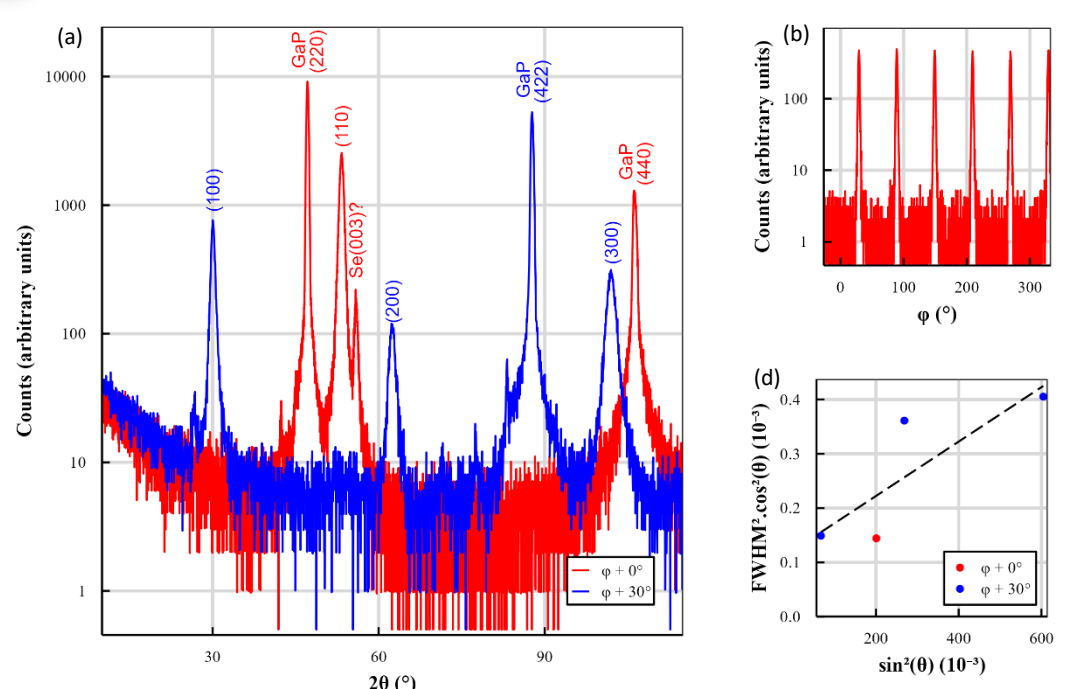


Obtained phases



[2] Y. Nakata, et al., "Selective fabrication of Mott-insulating and metallic monolayer TaSe₂", *ACS Applied Nano Materials* 1.4 (2018), pp. 1456–1460.
[3] Y. Nakata et al., "Robust charge-density wave strengthened by electron correlations in monolayer 1T-TaSe₂ and 1T-NbSe₂", *Nat Commun* 12 (2021), p. 5873

XRD analysis of 6MLs 2H-TaSe₂



→ TaSe₂ well oriented along GaP directions :
TaSe₂ [0001] // GaP (111)
TaSe₂ [10-10] // GaP (-211)

$$\beta_m^2 = \beta_{instr}^2 + \beta_{size}^2 + \beta_{strain}^2$$

$$\beta_m^2 - \beta_{instr}^2 = (4\varepsilon \tan \theta)^2 + \left(\frac{k\lambda}{\tau \cos \theta}\right)^2$$

$$(\beta_m^2 - \beta_{instr}^2) \cos^2 \theta = (4\varepsilon)^2 \sin^2 \theta + \left(\frac{k\lambda}{\tau}\right)^2$$

→ Broadening due to both crystallite size and strain (defects)
→ Crystallite size = 12 nm

AFM, STM and LEED imaging of 1ML 1T-TaSe₂

