



HAL
open science

Ohmic contacts by phosphorous ion implantation on (111) N-type CVD Diamond

Josiane Tasselli, Lya Fontaine, Karine Isoird, Patrick Austin

► **To cite this version:**

Josiane Tasselli, Lya Fontaine, Karine Isoird, Patrick Austin. Ohmic contacts by phosphorous ion implantation on (111) N-type CVD Diamond. 31st International Conference on Diamond and Carbon Materials, Sep 2021, ONLINE, Spain. , 2021. hal-03445509

HAL Id: hal-03445509

<https://laas.hal.science/hal-03445509v1>

Submitted on 1 Aug 2024

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.

Introduction

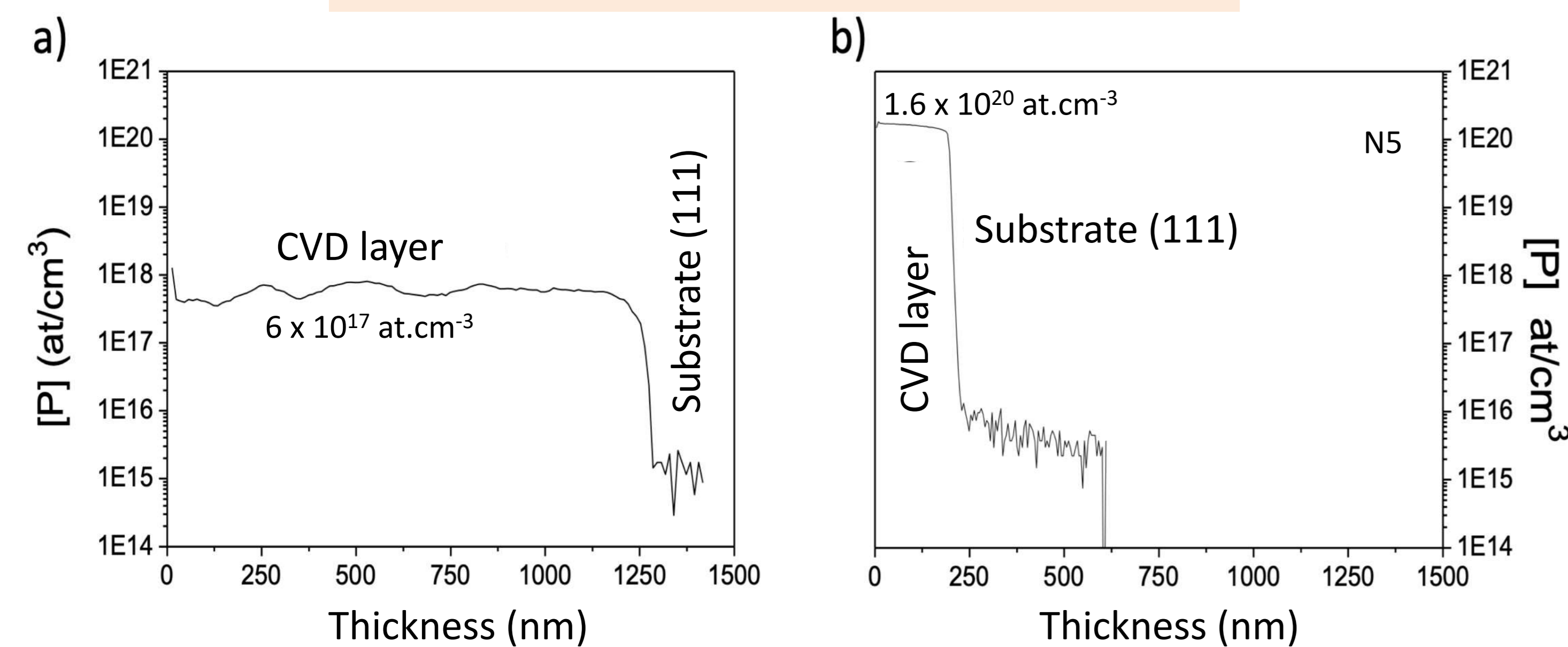
- Development of ohmic contacts on (111) n-type CVD 2x2 mm² diamond
- Study of different n-doping techniques by beam line and plasma immersion ion implantations
- Characterization of contact resistances by linear and circular-type TLM structures

Characteristics of studied samples

- N₂ to N₄**: n⁺-doping by beam line and plasma-immersion ion implantations on 6 x 10¹⁷ at.cm⁻³ phosphorous-doped epitaxial layers
- N₅**: 0.2 μm thick n⁺-layer grown on (111) diamond and heavily doped with [P] = 1.6 x 10²⁰ at.cm⁻³

Sample	n-epitaxial layer	Phosphorous overdoping by ion implantation
N ₁	1.3 μm / 6 x 10 ¹⁷ at.cm ⁻³	CVD reference (non implanted)
N ₂	"	- Beam line - HT annealing: 1700°C, 30min - Dopant atoms concentration: 5 x 10 ¹⁹ at.cm ⁻³ over 100nm measured by SIMS
N ₃	"	- Plasma-immersion: PH ₃ plasma at 20 keV - HT annealing: 1700°C, 30min
N ₄	"	- Plasma-immersion: PH ₃ plasma at 20 keV - HT annealing: 1700°C, 30min
N ₅	0.2μm / 1.6 x 10 ²⁰ at.cm ⁻³	- Heavily phosphorous-doped in situ, non implanted

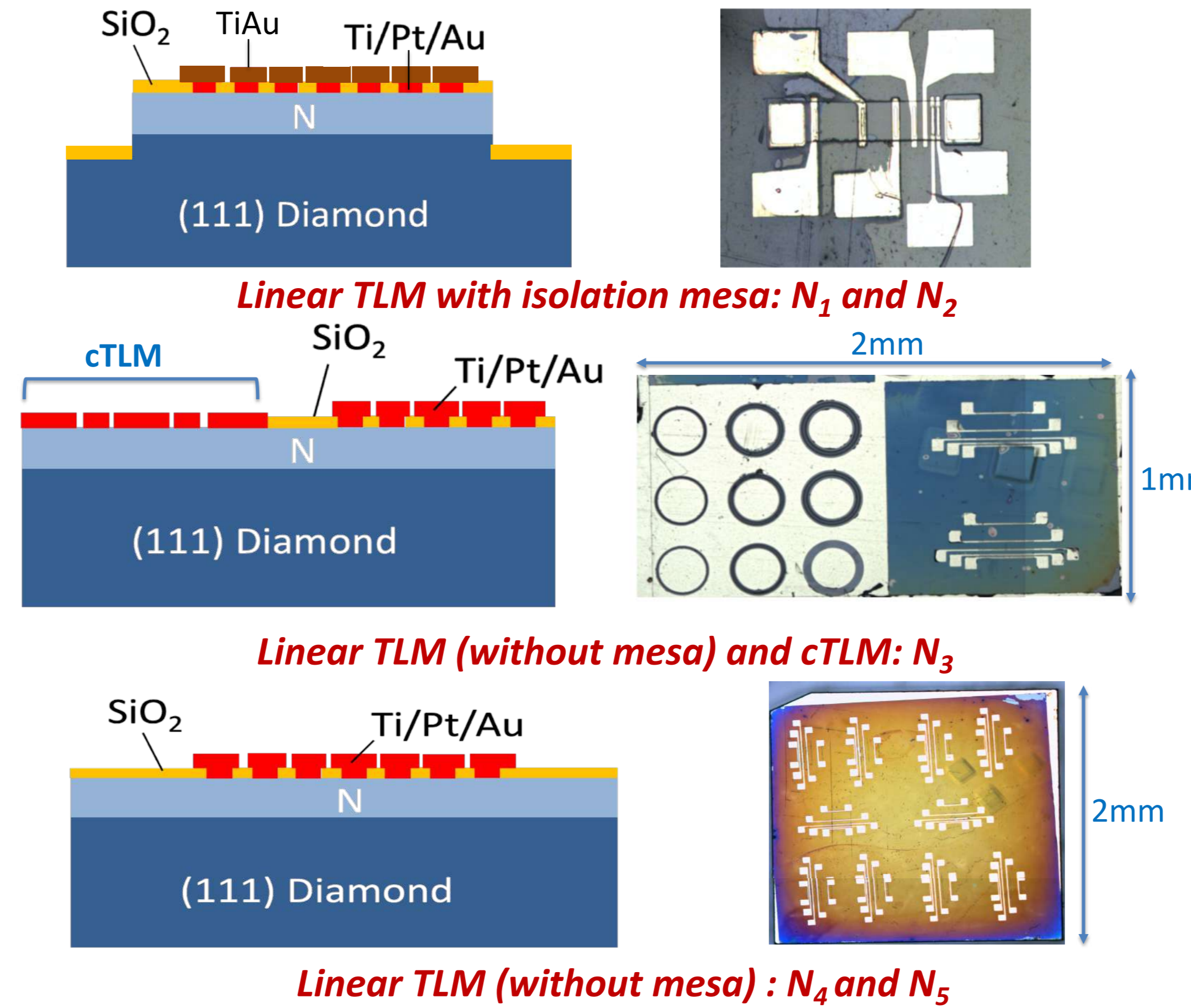
SIMS depth profiles of CVD n-layers



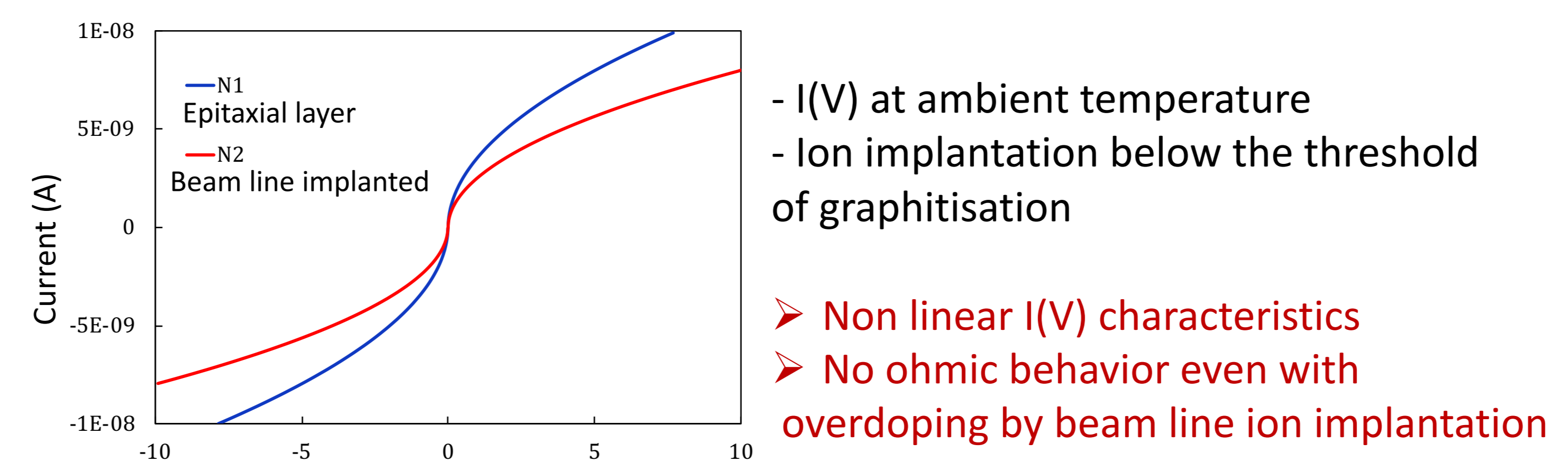
a) phosphorous-doped layer by CVD before ion implantation (N₁-N₄ samples)

b) heavily phosphorous-doped layer by CVD (N₅ sample)

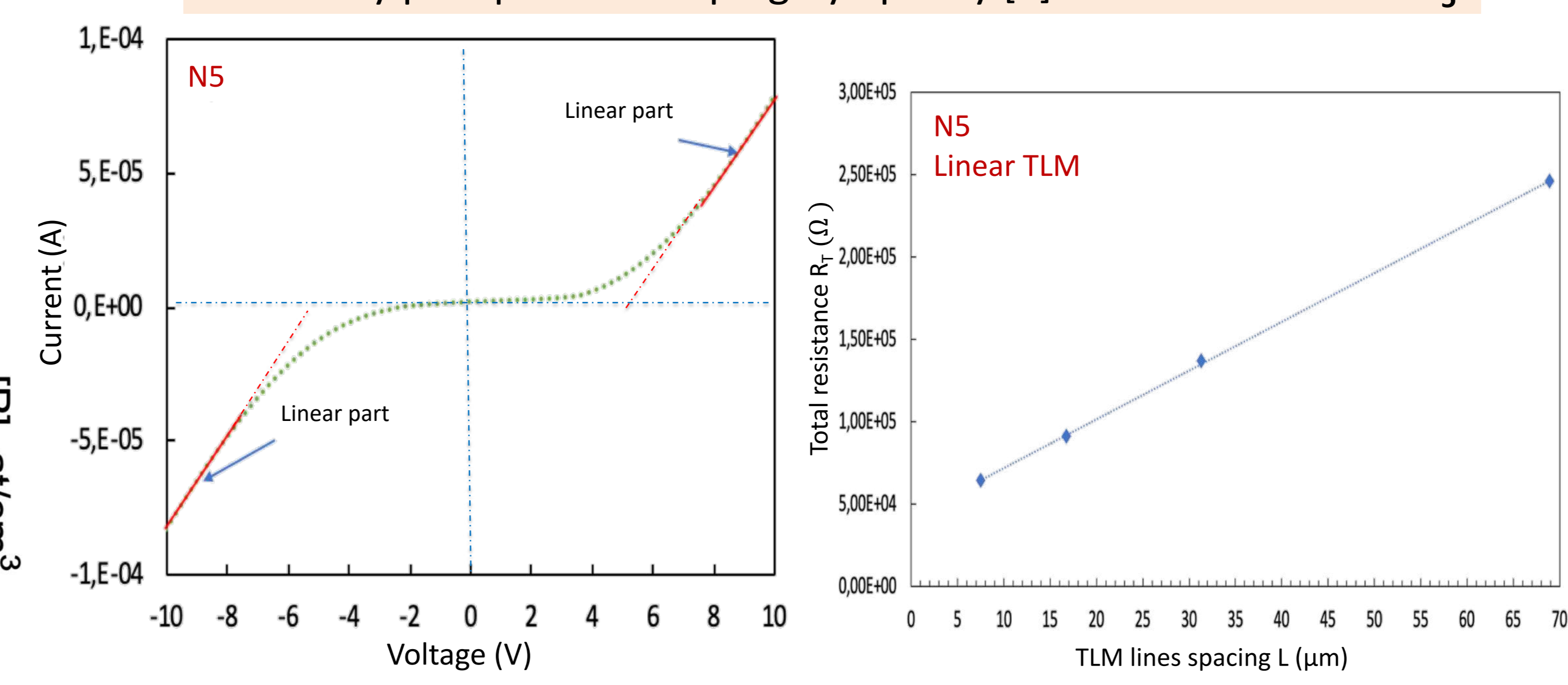
Fabrication and characterization of TLM structures



Influence of overdoping by beam line ion implantation : N₁ and N₂



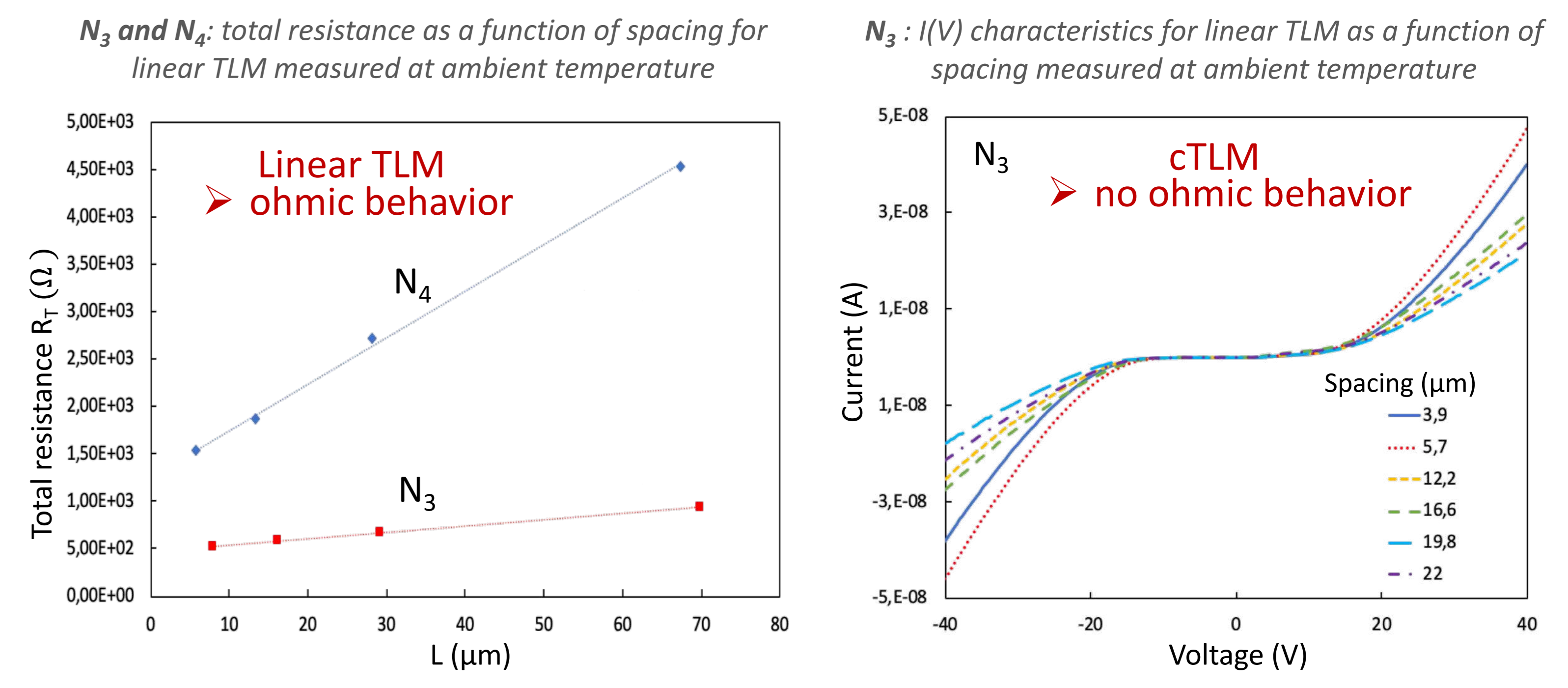
Heavily phosphorous doping by epitaxy [P]=1.6 x 10²⁰ at.cm⁻³ : N₅



Linear TLM	Sheet resistance	Specific contact resistance
N ₅	R _{SH} = 0.6 MΩ/□	ρ _C = 4.9 x 10 ⁻¹ Ω.cm ²

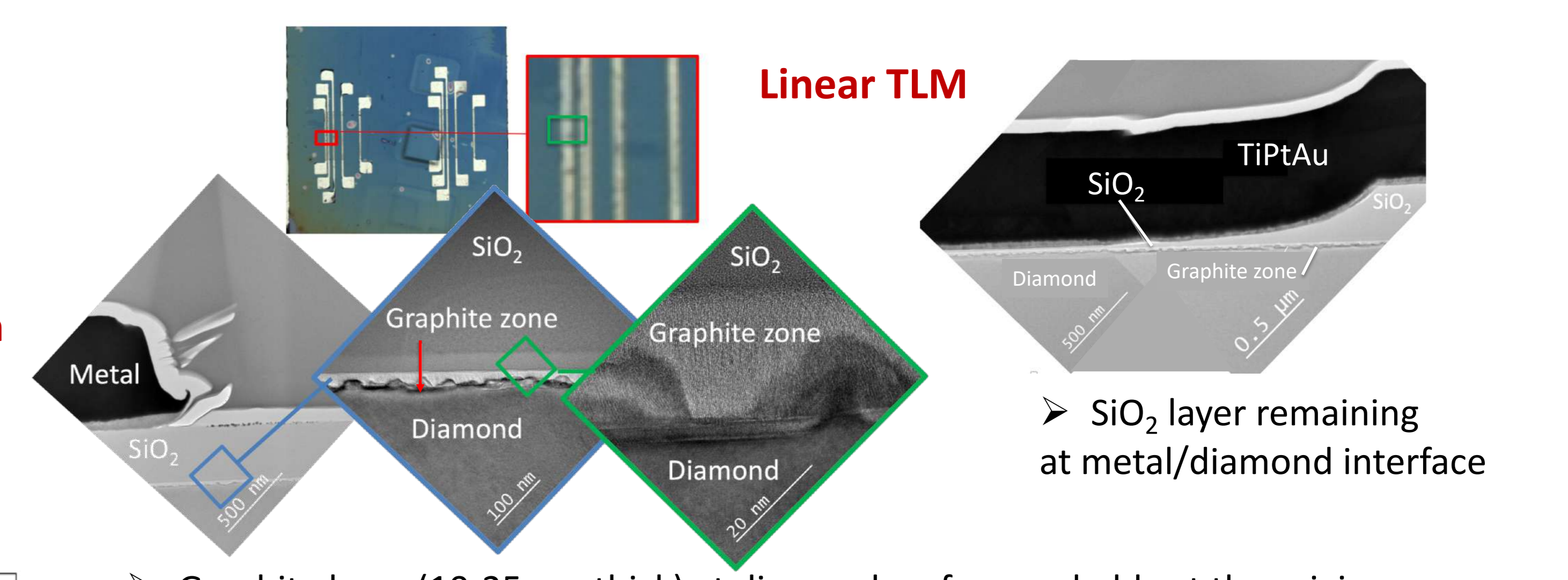
Difficulty to achieve ohmic contacts on heavily phosphorous-doped epitaxial layers

Phosphorous overdoping by plasma-immersion implantation: N₃ and N₄



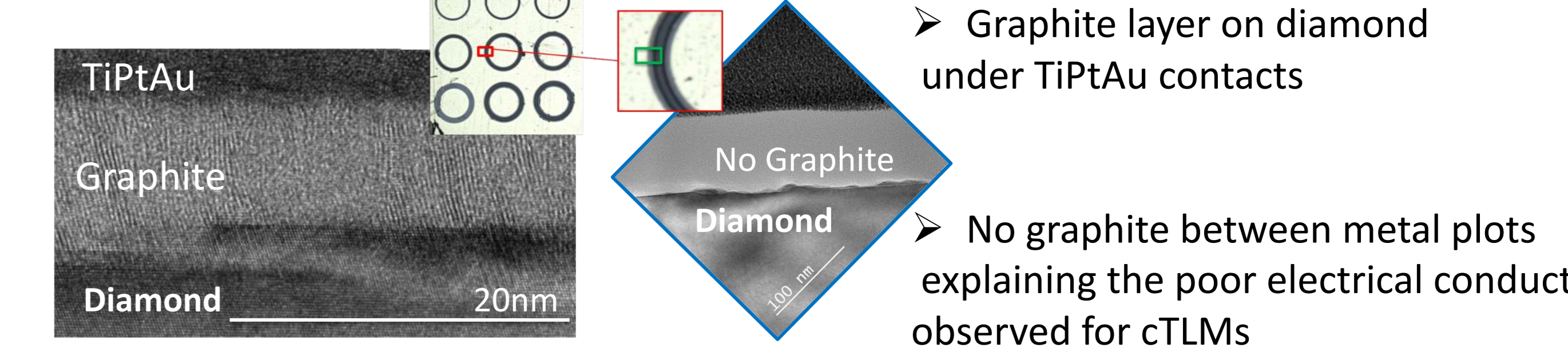
Linear TLM	Sheet resistance	Specific contact resistance
N ₃	R _{SH} = 1.5 kΩ/□	ρ _C = 1.7 x 10 ⁻³ Ω.cm ²
N ₄	R _{SH} = 9.7 kΩ/□	ρ _C = 6.7 x 10 ⁻² Ω.cm ²

TEM characterizations performed on N₃



Graphite layer (10-25 nm thick) at diamond surface probably at the origin of the electrical conduction observed

Circular TLM



Conclusion

- No ohmic contact obtained with highly phosphorous-doped epitaxial layer or by beam line implantation overdoping
- Ohmic behavior with plasma-immersion ion implantation with PH₃ plasma at 20keV and 10¹⁴ at/cm³ with the formation of a conducting graphite layer
- Studies are on going to explain the graphite layer formation and for testing new PIII implantation conditions