GaN Growth Using GaN Buffer Layer

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Presented by E. Gualtieri

Introduction

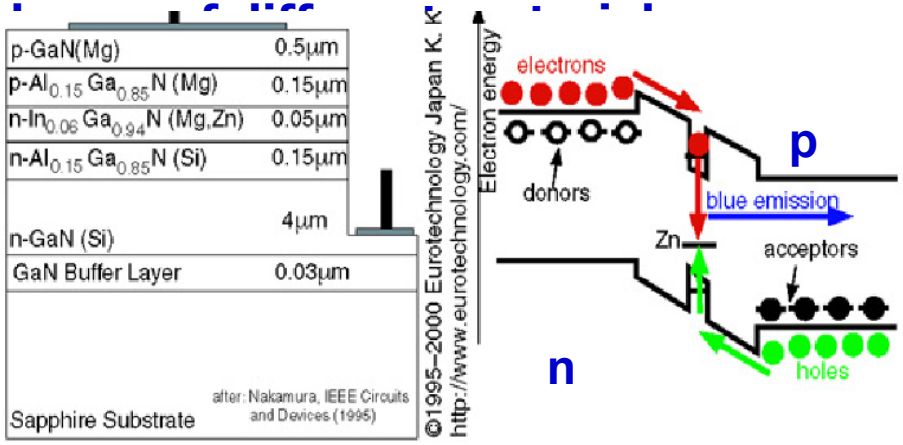
BLUE LED and LASER

What are?

- **Optoelectronic devices emitting <u>blue light</u>: λ_{blue} = 450 *nm***

- **demonstrated: λ_{eff} = *(360-480) nm***

- **stack of extremely thin and precisely grown semiconductors**



Why?

- **medical applications**
- **lighting applications (traffic lights)**
- **scanners and displays (TV)**
- **data storage**

Blu-ray tech

- **12/8/2004: 1st BD-ROM (1.0)**
- **23/5/2006: HD-CINEMA**
- **Nov. 2006 – Mar. 2007: PS3**

Recently a multi-players challenge:

SONY

TDK

JVC

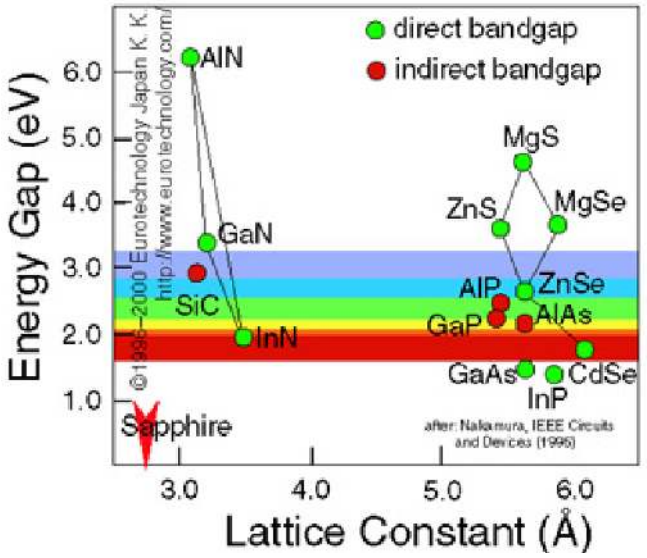
Introduction

MATERIALS

Needing of DIRECT BANDGAP

II-VI

- **heterojunction**
- **PROBLEMS: DEGRADATION, FAILURES**



NITRIDES

- **stronger, very high efficiency**
- **PROBLEMS: LACK OF SUBSTRATES, DISLOCATIONS**

SiC:

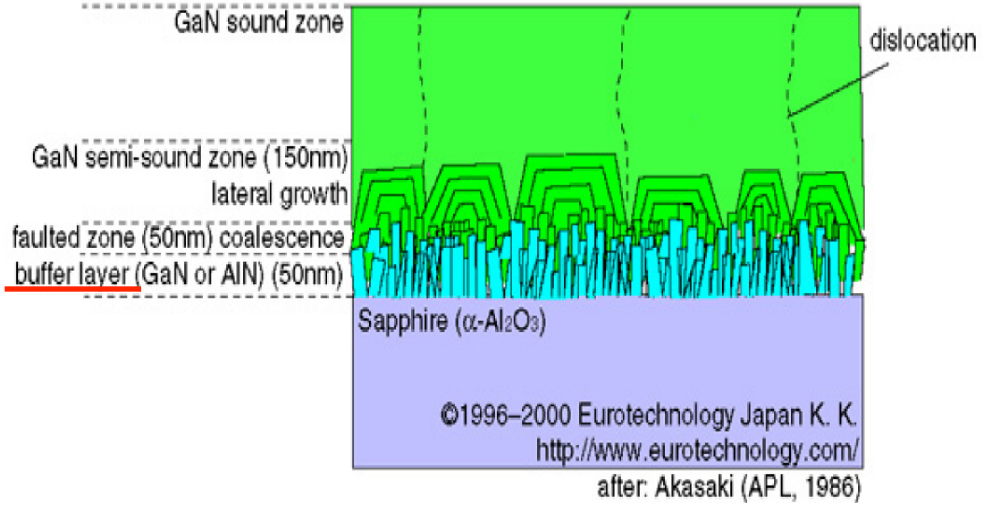
good lattice matching

very expensive

Sapphire:

widely used at present

15% lattice mismatch

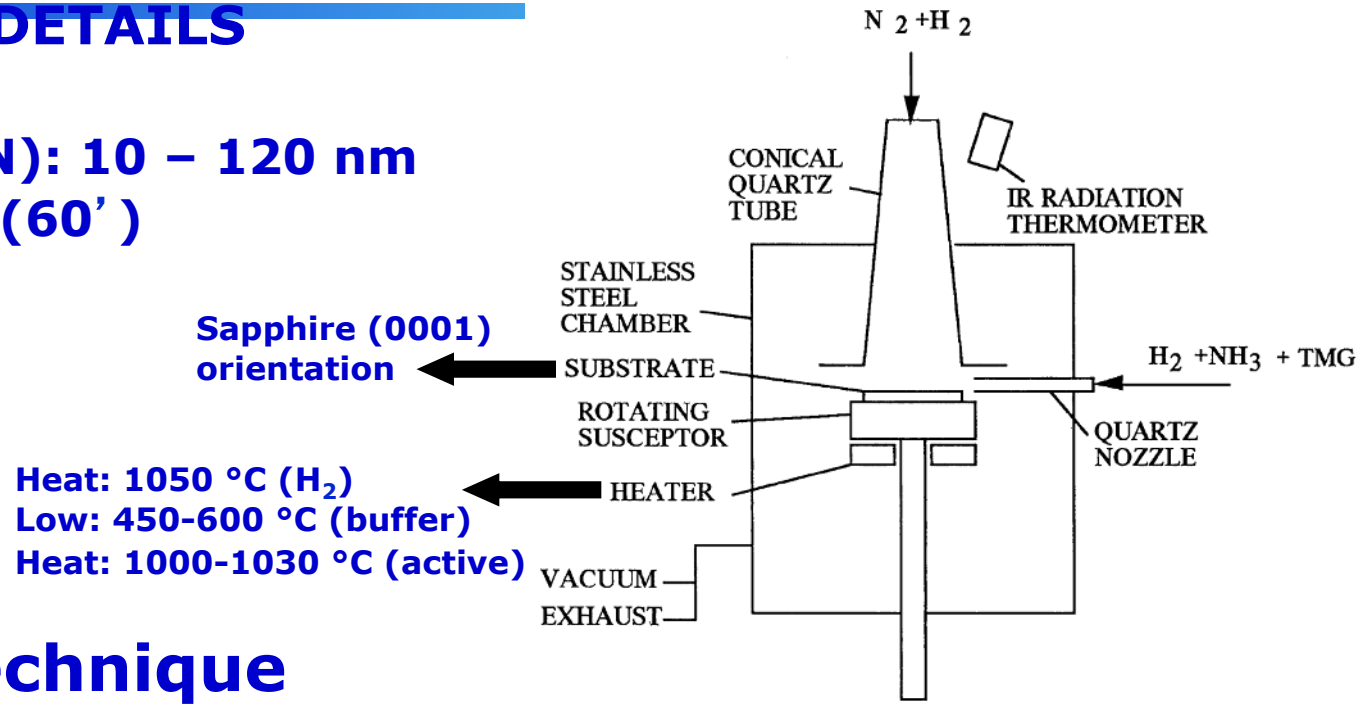


IDEALLY: GaN as substrate

Nakamura's solution

EXPERIMENTAL DETAILS

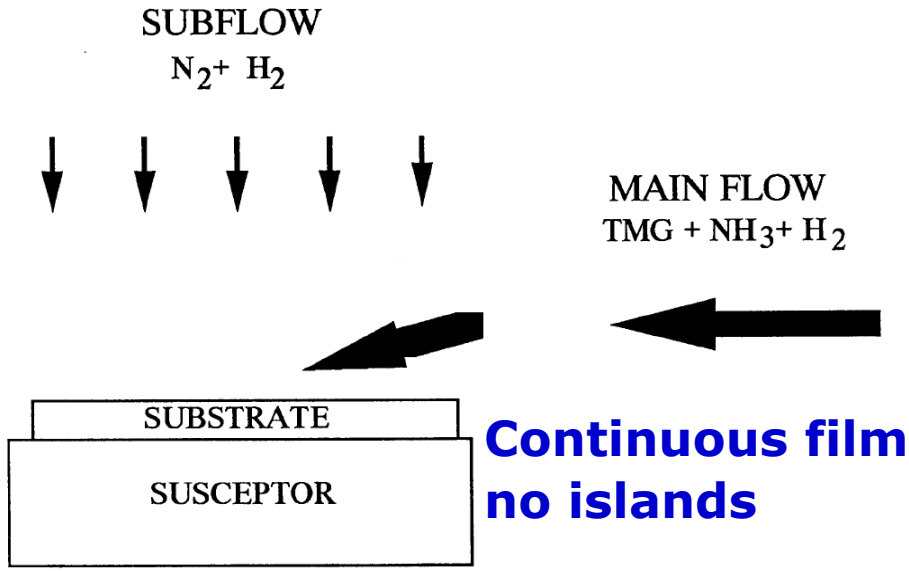
Buffer layers (GaN): 10 – 120 nm
Film (GaN): 4 µm (60')



TFMO-CVD Technique

Two different gas flows

- **MAIN: carries the precursor gas parallel to substrate**
- **SUB: changes the direction of the MAIN to bring the reactant into contact with surface**



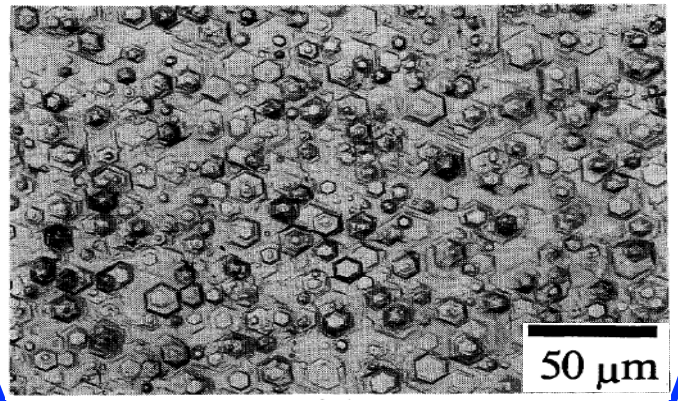
Continuous film, no islands

Nakamura's solution

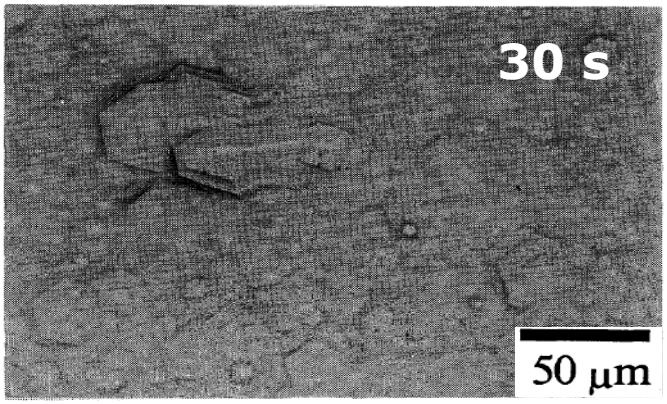
RESULTS - Surface interference micrographs

Many small hexagonal 3D island were observed

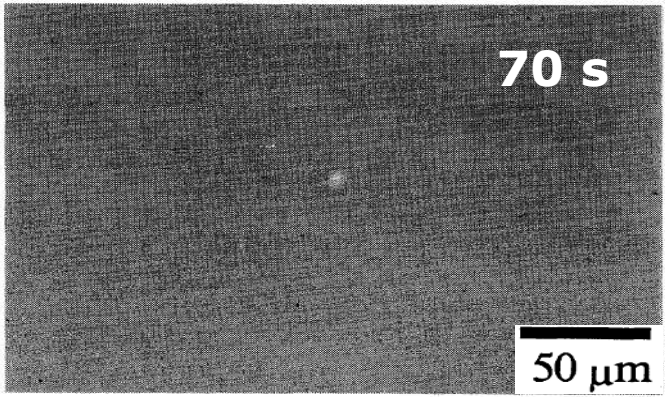
Without GaN buffer layer



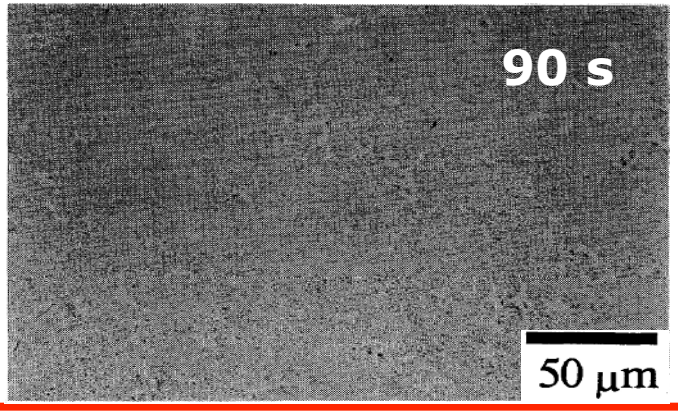
With GaN buffer layer



Few Hexagonallylike Pyramid growth



Uniform Mirrorlike Surface



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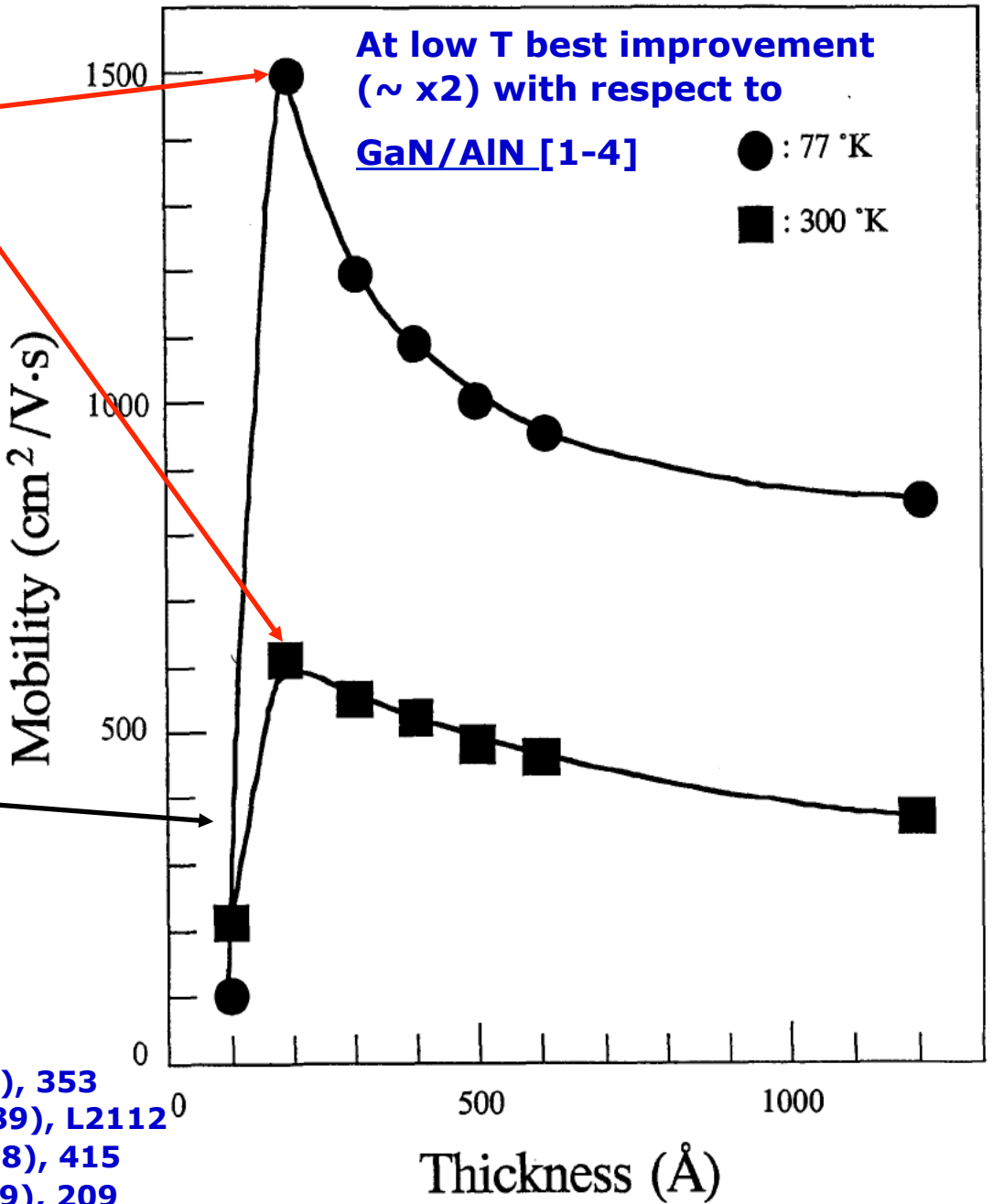
RESULTS – Hall mobility

Peak at 20 nm thick

At low T best improvement (~ x2) with respect to GaN/AlN [1-4]

For 10 nm thick mobility sharply decreases



1. Amano et al.. *Appl. Phys. Lett* 48 (1986), 353
2. Amano et al.. *Jpn. J. Appl. Phys* 28 (1989), L2112
3. Amano et al.. *Thin Solid Films* 163 (1988), 415
4. Akasaki et al.. *J. Cryst. Growth* 98 (1989), 209

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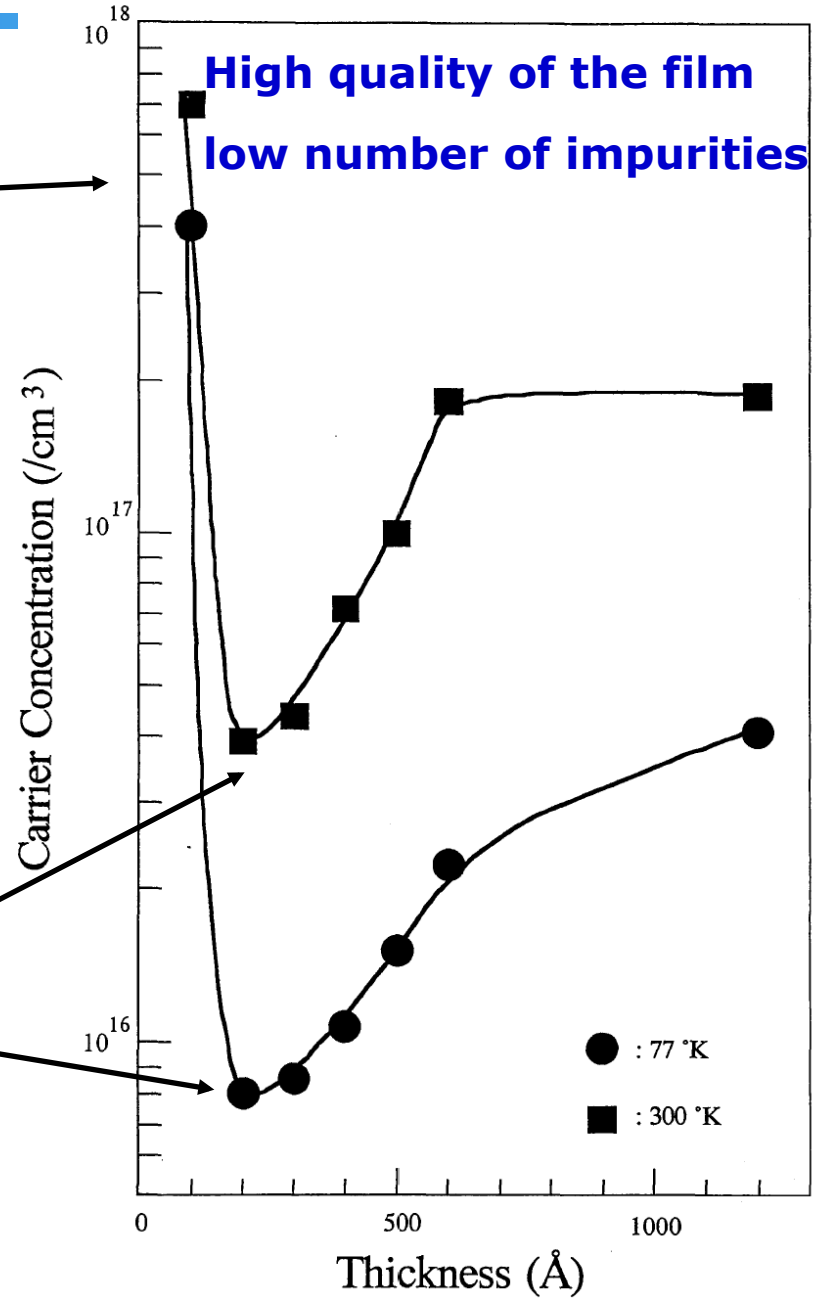
RESULTS – Carrier concentration

For 10 nm thick carrier concentration sharply increases

High quality of the film

low number of impurities



For 20 nm thick, carrier concentration is one order lower with respect to GaN/AlN [1-4]

1. Amano et al.. *Appl. Phys. Lett* 48 (1986), 353
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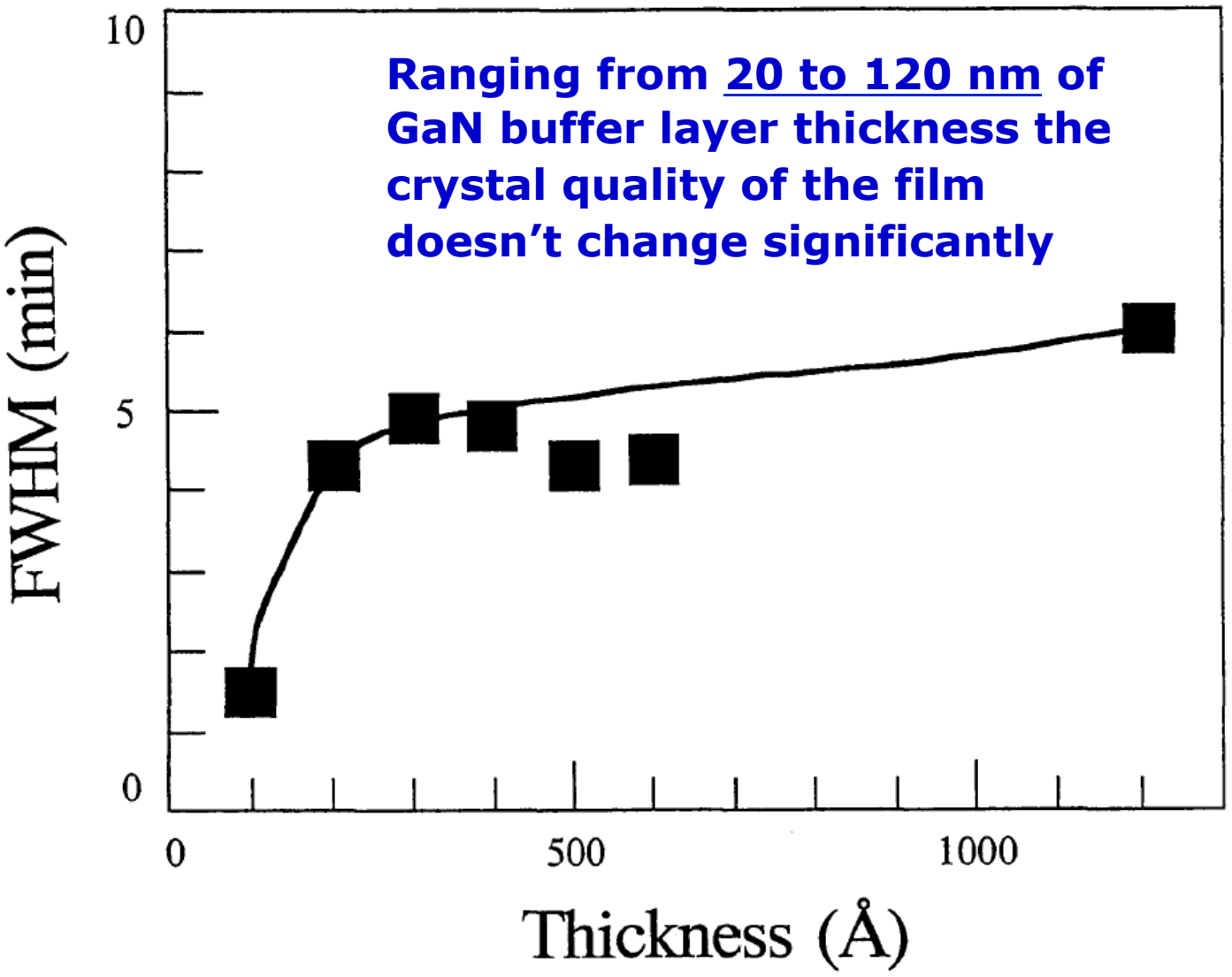
Nakamura's solution

RESULTS – Crystal Quality (XRC)



Conclusion

- 80s challenge: in the field of materials research for BLUE LIGHT OPTO-DEVICES
- NITRIDES replace II-VI h-junct
- But there was a lack of suitable substrates for growing them
- In 1991, S. Nakamura illustrates a TFMO-CVD process that demonstrates the possibility to grow above Sapphire wafers a high-quality GaN/GaN combination
- 4 μm-GaN film on 20 nm-GaN buffer layer gives better performances with respect to "Amano-Akasaki GaN/AlN solution" (1986-89)
- Mirrorlike surface, higher Hall mobility, lower density of impurities, good crystal quality were shown

THANK YOU FOR KIND ATTENTION AND SORRY FOR MY AWFUL ~~I~~NGLISH!

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