Growth and Characterization of InGaN/GaN core-shell structures by molecular beam epitaxy

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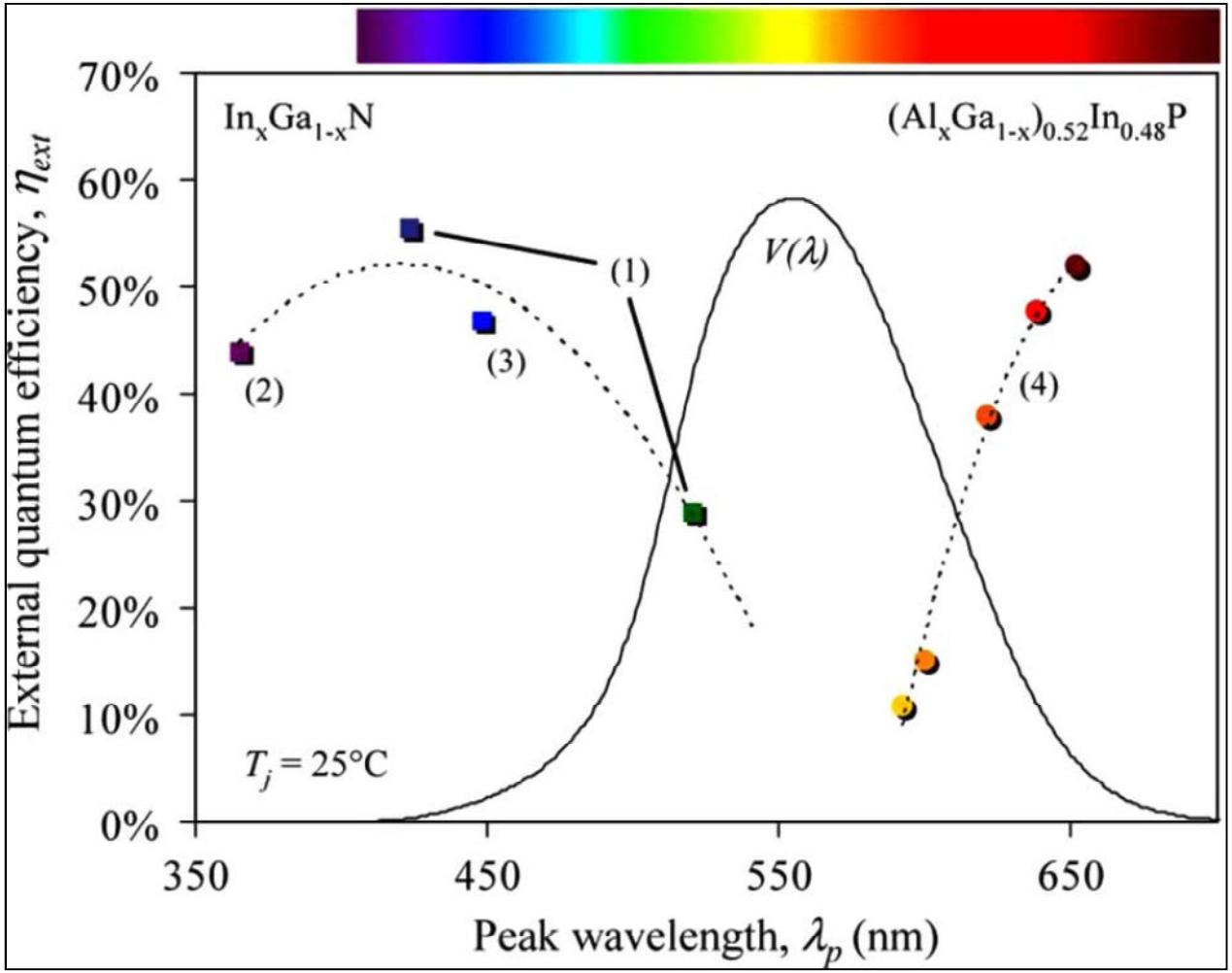
Introduction (1)



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Efficiency drop in the green–yellow region in planar InGaN structures associated with:

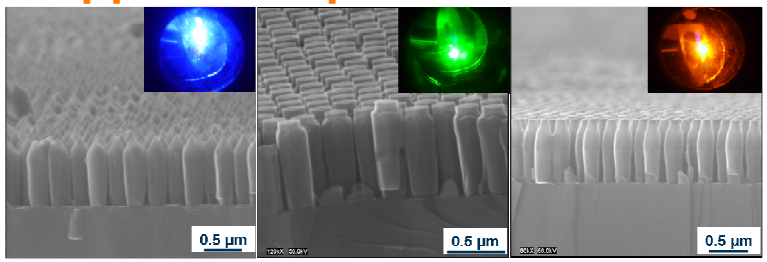
- high defect density
- high spontaneous and piezoelectric polarization

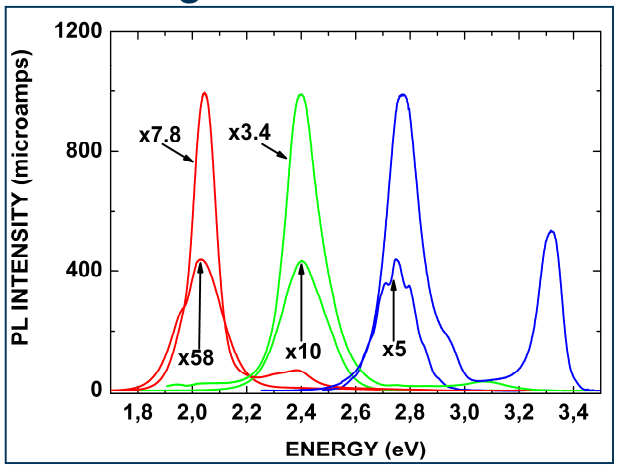
→ solution:
SAG NANOCOLUMNS (NCs):

superior over self-assembled NCs in terms of homogeneity, processing and colour control

Introduction (2)

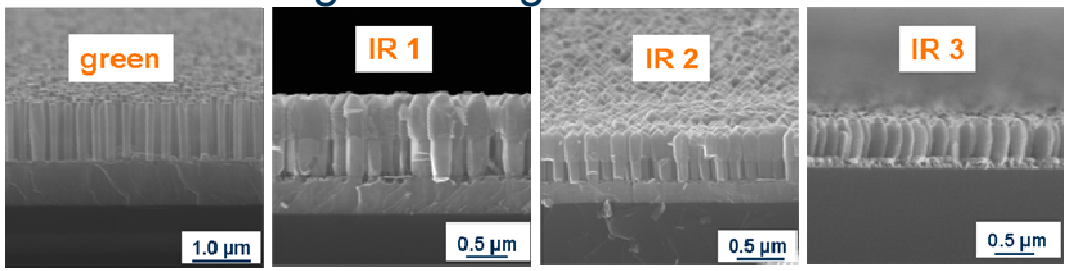
- selective area growth of (bulk) InGaN/GaN NCs allows for single color emission on **GaN/sapphire templates**

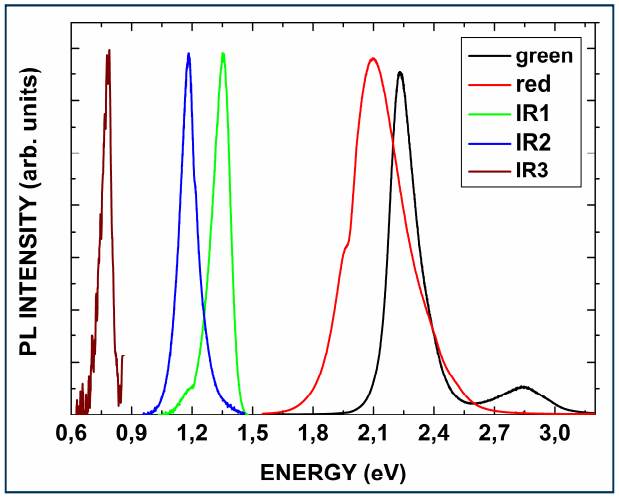




S. Albert, A. Bengoechea-Encabo et al., J. Appl. Phys. 113, 114306 (2013);
S. Albert et al., Appl. Phys. Lett. 102, 181103 (2013)

- SAG (bulk) InGaN/GaN NCs with an In content of up to 100 % were grown on **Si(111)** → PL-IQE up to 30% in the green range



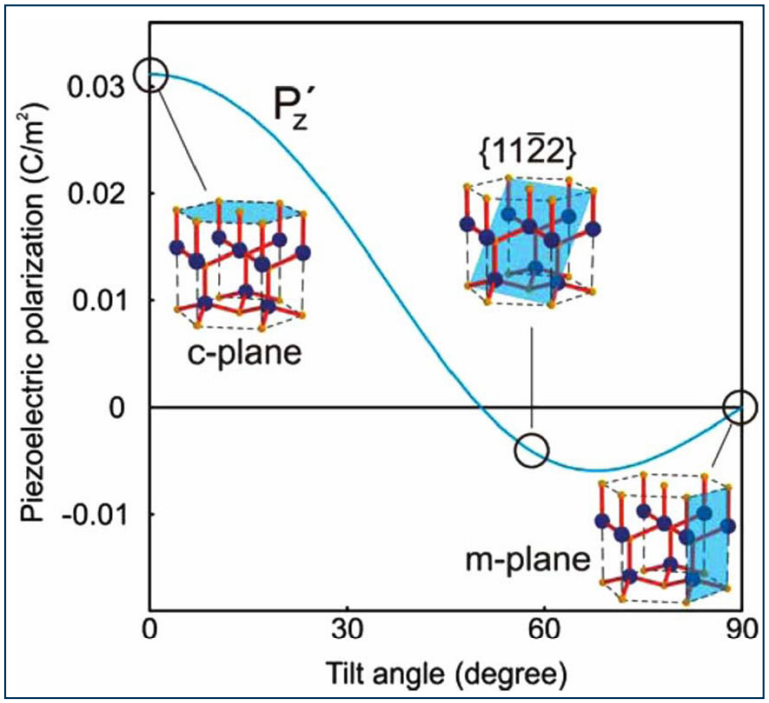


- still polarization effects due to growth on c-plane

solution: growth along semi-polar or non-polar direction

S. Albert, A. Bengoechea-Encabo et al., Nanotechnology 24, 175303 (2013)

Introduction (3)



- growing active region on semi-polar or non-polar facets

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reduces the polarization effects in wurtzite materials

- problem: high defect density in effordable non- and semipolar substrates

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Solution:

1. Free standing non-polar HVPE substrates → **very expensive** ☹
2. Growth of active material on semipolar facets of c-plane GaN NCs
   [***S. Albert, A. Bengoechea-Encabo et al. Appl. Phys. Lett., 100, 23 (2012)***]
3. Find new ways to get high quality substrates → coalescence of NCs with very high quality
   [***S. Albert, A. Bengoechea-Encabo et al., Appl Phys. Lett., accepted***]
4. Growth on non-polar m-plane sidewalls of GaN NCs→ **InGaN core-shell**

Introduction (4)

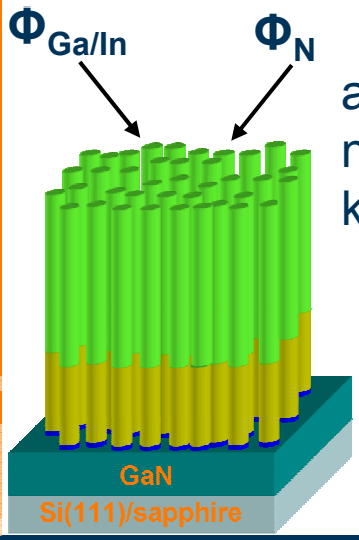
- growth of InGaN/GaN core-shell structures already achieved some years ago using MOCVD [**Fang Qian, Yat Li, Silvija Gradecak, Deli Wang, Carl J. Barrelet, Charles M. Lieber, Nanoletters, 4, 10, (2004)**]

- Why bother to grow InGaN/GaN core-shell structures by PA-MBE?

  potential for high(er) In-content core-shell structure → may allow for core-shell RG(Y)B emitters and tandem solar cells

- approach:

axial



axial InGaN/GaN structures need shadowing effects for keeping selectivity

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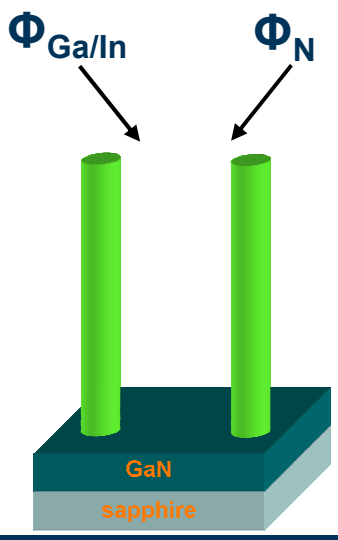
small pitch needed

core-shell



shadowing has to be prevented to allow for growth on m-plane

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high pitch needed
long NCs needed → use of micro-columns

outline

- Limitation of bottom up SAG by PA-MBE
- InGaN core-shell growth on etched GaN pillars
- InGaN core-shell growth on MOVPE grown pillars
- Potential of PA-MBE for high In-content core-shell structures
- Summary