Over the past decade, considerable attention has been given to the growth of InGaN epilayers for photovoltaic applications. Such applications require the growth of epilayers with high indium contents, but, most importantly, with a thickness of over 100nm. At such thicknesses material quality has been shown to rapidly deteriorate, and the epilayers become rough, compositionally inhomogeneous, and highly defective. In a recent contribution, the present group proposed that by periodically inserting ultra-thin GaN layers during the growth of the InGaN epilayer, one could suppress the fluctuations in the indium composition, and thereby produce high quality epilayers that meet the requirements for photovoltaic applications. An experimental demonstration of the improvement that could be obtained using this semi-bulk growth process was given with InGaN epilayers containing 8% indium. In the present contribution, the most advanced transmission electron microscopy techniques are combined for the first time to evaluate the improvement obtained in semi-bulk InGaN epilayers grown by MOVPE. The epilayers used in this study contain 16% indium, double that of the previous contribution for a similar thickness. Particular attention is given to the strain and luminescence of these epilayers. More specifically, electron holography in a transmission electron microscope (HoloDark) was used to map the deformation in both the growth and the in plane directions with nanometric resolution. The results show that the semi-bulk InGaN epilayers are pseudomorphically strained on the underlying GaN substrate (see Fig.1). Furthermore, cathodoluminescence in a scanning transmission electron microscope (STEM-CL) was used to map the luminescence of these epilayers at the nanometer scale. A single, sharp emission is observed throughout the epilayers where the compositional fluctuations have been successfully suppressed (see Fig.2). These results serve to showcase the potential of semi-bulk InGaN for optoelectronic applications. Potential pathways to demonstrating epilayers with higher indium contents are discussed.

Acknowledgement: The authors kindly acknowledge support from the French CNRS RENATECH network and from the French METSA network.
Fig. 1: (left) HAADF STEM image of the semibulk InGaN epilayer; (middle) Mapping of the deformation along the c axis; (right) mapping of the deformation along the a axis.

Fig. 2: (left) HAADF-STEM image of the zone mapped in STEM-CL; (middle) Observed luminescence peak; (right) mapping of the intensity of the observed peak.