Introduction Thin-film periodically poled lithium niobate (TFLN) waveguides have found applications in second-harmonic generation (SHG) [1], entangled photon-pair generation [2], optical parametric amplification [3], as well as all-optical switching [4]. Tight confinement of the optical modes in these waveguides combined with the high nonlinearity of lithium niobate enables high normalized nonlinear conversion efficiencies, but at the same time increases sensitivity to fabrication errors compared to their bulk counterparts [5,6]. These errors can lead to peak broadening and undesired side lobes in the QPM spectrum, resulting in reduced efficiency. Though numerical analysis for possible sources and effects of fabrication errors has been reported [5], comparisons with experimental results are still lacking to fully evaluate and understand these influences. Here, by using a combination of scattered light imaging, direct measurements of the QPM spectrum, and numerical simulations, we elucidate the causes of imperfections in the QPM spectrum of TFLN frequency doublers.

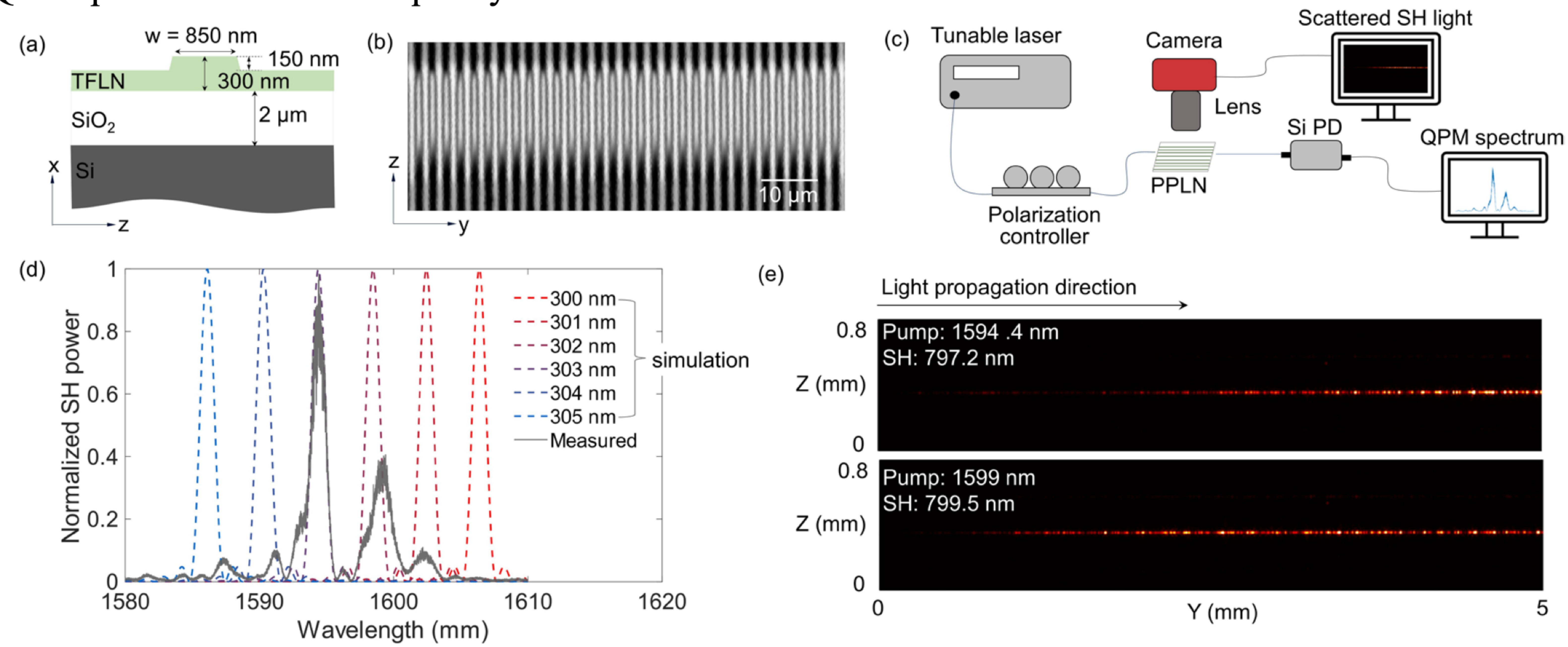

Fig. 1. (a) Cross-section of the PPLN waveguides. (b) Second-harmonic microscope image of the PPLN. (c) Schematic of the experimental setup for SHG characterization. (d) Comparison of the measured QPM spectrum with the calculated curves for different film thicknesses. (e) Images of the scattered SH light with the pump wavelengths at 1594.4 nm (the main peak) and 1599 nm (the side lobe).

Results and Discussion We design and demonstrate thin-film PPLN waveguides for efficient SHG from telecommunication wavelengths to near-visible wavelengths around 800 nm. As shown in Fig. 1(a), the waveguide is formed by half-etched 300-nm thick x-cut TFLN, with a top width of 850 nm and a 5 mm-long periodically poled region. To achieve QPM, the required poling period is only 2.46 μm, which is among the shortest periods demonstrated so far. Figure 1(b) presents a typical second-harmonic (SH) microscope image of the poled area, showing domain structures with ideal uniformity and duty cycles, which is crucial for efficient frequency conversion.

The QPM spectrum is usually characterized by measuring SH power at the output facet of the waveguides, which gives the total SH power generated through the entire PPLN region. As shown in the experimental setup in Fig. 1(c),