Figure 5 shows the radio frequency (RF) spectra of the fundamental beat note at 507.3 and 503.4 MHz recorded with a resolution bandwidth of 1 kHz and the 5-GHz wide-span RF measurements (insets) for the SWCNT-SAM and graphene-SAM mode-locked Yb:KLuW laser. Very high extinction ratios of >80 dBc and the absence of any spurious modulations are evidence for clean single-pulse mode-locking of both SAM mode-locked Yb:KLuW lasers. Lower signal intensities at higher frequencies in the wide-span measurements are attributed to the limited bandwidth of the available photo diode.

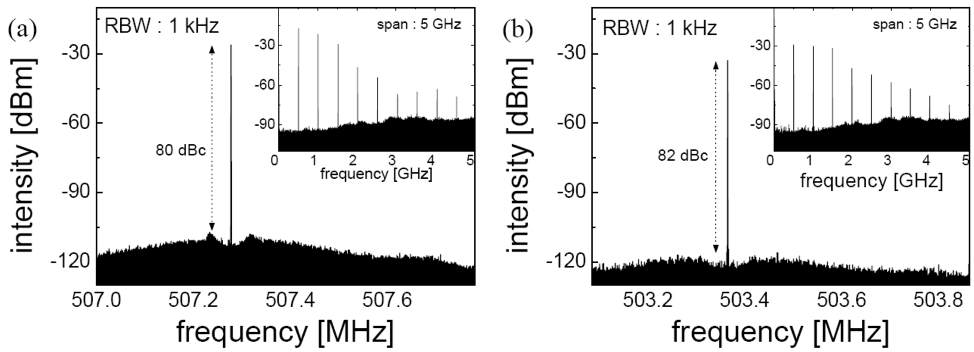

Fig. 5. RF spectra of the fundamental beat note and wide-span measurements (insets) of the (a) SWCNT-SAM and (b) graphene-SAM mode-locked Yb:KLuW laser.

4. Conclusion

We develop a unique carbon nanostructure-based SAM by deposition of SWCNTs and graphene on a single dielectric mirror for the first time and demonstrate its multi-functional application in a diode-pumped 500-MHz mode-locked Yb:KLuW laser operating near 1050 nm. Maximum average output power of up to 85 mW and pulse duration as short as 157 fs are generated with 1% OC. Improvements of the mode-locked laser performance including pulse duration, efficiency, and power scaling are possible by further optimization of SAM parameters and intra-cavity dispersion, output coupling ratio and pump characteristics. Nevertheless, the results achieved in the present work show the potential of diode-pumped carbon nanostructure-mode-locked solid-state lasers as robust and cost-effective solutions for developing >1 GHz repetition rate femtosecond lasers.

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