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Despeckling Light Sources by Linear and Nonlinear Photonics Crystals

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1. Introduction

Coherent light sources are important tools for many of scientific investigations and practical applications. However, for imaging and display applications, optical coherence can cause side effects such as speckle to degrade the image quality. Here we report the use of nonlinear and linear photonic devices to suppress the laser speckle contrast ratio below 4.5%**.**

2. Device Structures and Characterization

(a)Nonlinear photonic devices

We used a multi-QPM periodicity structure design in a PPLN device with phase apodization to facilitate simultaneous second-harmonic and sum-frequency generation processes to form spectrally broadened green laser bands using a spectrally broadened IR pump laser. The latter was made from a degenerate-pumped PPLT oscillator to simulate a wide spectral tuning-range of the fundamental waves from 900 to 1200nm.

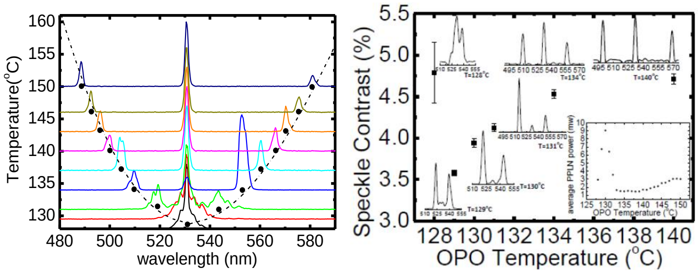

Fig.1 (a) spectra and (b) speckle contrast ratio by the broad-band green lasers

Illustrated in Fig.1(a) are the spectrally broad green lasers, composed of three bands each of ~ 5nm spectral width and spectrally tuned over the 490 nm to 580nm range. From the still-beam image analysis, we measured the speckle contrast (SC) as the ratio between the standard deviation and the average beam intensity. This remarks dramatic (~20 fold) reduction of SC less than 4.5% from an initial value of ~65% from a SHG green laser of 0.2nm spectral. This observation confirms a recent prediction in the spectral width relation to the speckle value in Ref.[1] In comparison, previous SC data using three-wavelength SFG/SHG green lasers composed of ~0.1nm spectral width and 0.5nm peak separation only reduced from the initial value by $1/\sqrt{3}$ Ref.[2]

(b)Linear photonic devices

To take advantage of the phase-diversity to suppress the laser speckle as taught in the text, we resorted to bi-refringent photonic devices to provide such additional modulation effects. These devices were characterized by sub-wavelength surface structures and can be attached to the exit window of a scanning type projector and operated in a wide spectral range. We followed a recently proposed speckle measurement procedures outlined in Ref. [3] by selecting CCD parameters of: pixel area of (4.65□m)^2, f/# of 4, and integral time of 60ms. As illustrated in Fig.2, the fast axis of the MEMs scanning mirror was running at 44KHz, we denote SC reduction from its original value of 7% to 4.5% when a large imaging area (3×3 cm^2 of 1024 ×1024 CCD pixels) was measured

Fig.2 The measured speckle contrast ratio by subwavelength photonic devices (b) as attached to scanning projector

3. Conclusions

We demonstrate methods to suppress the laser speckle issues by invoking the mechanism of wavelength diversity and phase diversity on nonlinear and sub-wavelengh bi-refringent photonic devices, separately.

Acknowledgements

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References

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