other high speed IOS techniques [22]. Current system resolution of 7.4 μm enables a field of view of 4-8 mm. Further studies currently underway are using higher magnification of 2 × or 4 × , achieving subcellular resolution, with a trade off in SW noise. However, further frame averaging can easily be implemented to reduce this effect and achieve appropriate temporal resolutions.

We see future applications of this approach in live animal studies with chronic portable imaging sensors mounted over the skull over longer time periods. Ongoing studies aim to implement this technique to demonstrate simultaneous portable ISOI and LSCI imaging, using a single VCSEL light source (e.g. at ~670 nm) with rapid alternation of the illumination scheme to minimize or maximize coherence effects. Importantly, such a flexible, highly dynamic illumination technique will allow for straightforward image co-registration between two independent brain imaging modalities. It can also be implemented in portable sensors for monitoring brain activity in freely behaving animals and in the future, for continuous monitoring of brain activity in patients. A further potential application of rapid current sweep in VCSELs is in fluorescence imaging, where speckle reduction allows for uniform high spatial resolution excitation of a marker or dye.

5. Conclusion

We have demonstrated that changing VCSEL operation between single mode and current sweep schemes can be used to manipulate its speckle noise properties, allowing us to use a single light source to image neural tissue via two different modalities: tissue oxygenation (ISOI) and blood flow (LCSI). We show that the current sweep scheme lowers the temporal and spatial noise of the VCSEL to approach values comparable to that of a low noise LED illumination. We attribute this to the combined effect of decreasing the coherence length of the source, and the spatial and polarization superposition of transverse modes that change in space and time (due to current sweep as well as brain movement). The use of VCSEL light sources for optical brain imaging will advance the development of a portable, head-mounted continuous imaging technique for studying the underlying neuronal activity in un-anesthetized animals, and continuous evaluation of brain activity and drug efficacy in clinical settings.

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