Dual Frequency Intravascular Ultrasound Transducers for Accurate Diagnosis of Atherosclerosis

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Atherosclerosis is caused by a chronic inflammatory process that develops in response to blood vessel injury. As a result of the process, plaque builds up in artery walls and leads to blood vessel narrowing. Under certain conditions, additionally, the plaque can be ruptured. These adverse events cause a heart attack. Therefore, atherosclerosis is known as the leading cause of death among the cardiovascular diseases. There are several indicators used for accurate diagnosis of atherosclerosis, such as the plaque burden, the degree of luminal stenosis, and thickness of the fibrous cap. In addition, the identification of plaque compositions is necessary to accurately assess the plaque vulnerability. When patients are suspected of atherosclerosis, angiographic assessment is conducted at first. Since angiography provides a projection image, it has a relatively high false-negative result when plaque vertically grows or positive remodeling occurs. To improve diagnostic accuracy, therefore, intravascular ultrasound (IVUS) imaging is performed. A catheter containing a high frequency ultrasound transducer is inserted into a blood vessel and rotated while pulled back for imaging. Although IVUS imaging has been used for diagnosis of atherosclerosis in clinics, the spatial and contrast resolutions of IVUS imaging are not high enough to accurately measure the diagnostic indicators. Recently, various IVUS transducers have been developed to tackle the problems: combined IVUS and OCT imaging probes, dual-frequency IVUS transducer, and dual-frequency focused IVUS transducer for tissue harmonic and frequency compounding imaging. In this presentation, the clinical indicators used in diagnosing atherosclerosis and the current limitations of IVUS imaging are described, and recently developed IVUS transducers are introduced. Especially, the theoretical background and imaging performances of those transducers are described in detail.