Group Velocity Measurements of Fast-Guided-Mode Photonic Crystal Silicon Comb Nanowires [°]Borriboon Thubthimthong¹, Kazuhiro Hane¹ E-mail: borriboon@hane.mech.tohoku.ac.jp

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The rapid expansion of multi-core very-large-scale integrations (MVLSIs) die real estate as a result of Moore's law has raised the fundamentally physical concerns whether metal interconnects can support the future MVLSIs in terms of both speed and distance. One of the promising solution is to replace the metal interconnects with nanophotonic silicon nanowires which are capable of supporting high bandwidth and long interconnect distance. Silicon nanowires in the forms of channel waveguides (CWs), ridge waveguides, and photonic crystal waveguides (PCWs) have been investigated extensively in the past. However, the signal propagation delay time-one of important characteristics of MVLSI interconnects-has not been much investigated. Our recent study on the PCWs of comb shapes (Fig.1) fabricated on SOI substrate shows that the waveguides not only possess reasonable theoretical bandwidth-distance figure (~1 Tb/s-cm) but also can reduce the propagation delay time by almost half when the fast guided modes are excited. The propagation delay time which is equal to propagation distance (L)divided by the signal group velocity (v_g) can be reduced when the group velocity increases. We develop an on-chip group index (n_g) measurement technique using integrated ring resonators shown in Fig. 2. By measuring the free spectral ranges (FSRs) of the ring resonators, the group velocity can be obtained via $v_{g} = (FSR)cL/\lambda^{2}$. The theoretical group velocities of the channel waveguides of various widths and thicknesses are calculated by the plane wave expansion theory and are plotted as shown in Fig. 3. The theoretical group velocity of the PCW is calculated and measured and is found to be around 0.36c which is almost two times of that of the channel waveguides. Good agreements on the group velocities obtained from the experiment and the plane wave expansion theory are found. Our future works involve further improvements on the measurement technique for better accuracy and for group velocity dispersion (GVD) measurement, and

optimization of the PCW to achieve highest possible group velocity while still maintaining GVD to an acceptable range.

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Fig.1. a-b) The PCW of comb shape c-d) The channel waveguide



Fig. 2. The on-chip group index measuring ring resonator can be integrated with either a) the CW or b) the PCW (b). The FSR is obtained from the ring resonator transmission spectrum shown in c) for the respective waveguides.



Fig. 3. CWs' v_g vs width. All v_g 's are less than PCW's v_g . Solid line denotes results from theory. Experimental results are in dots.