Quality of silicon substrate and point defects (6) IR absorption of CO, NN, NO ring

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シリコン結晶基板の品質と点欠陥 (6) CO, NN, NO ringの赤外吸収

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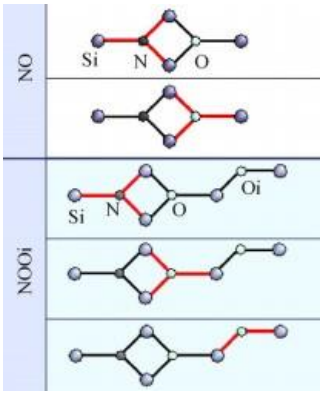
Silicon device has become the brain (=IC chip, from 1995/ cell in the neural network) and the heart (=power device, from 2005/ blood in the vascular network) of the world. Nitrogen doping in silicon is widely used to suppress both vacancy (V) and interstitial (I) type grown-in microdefects in the substrate for IC chip [1]. Dominant state of N was established to be Si-N-Si-N 4-atom **NN ring [2]**. Carbon is used to control lifetime of power device. Its configuration was found before to be **CO ring [3]**. Therefore, **the human life is constructed on this ring**. In addition, shallow thermal donor (STD) and O dimer (working for the precipitation, thermal donor formation and O fast diffusion) are composed of **NO** [4] and sometimes of **OO** ring [5], respectively. Therefore, it is necessary to understand them well. All of them show IR absorption by the local vibration modes (LVM) directly originating from individual atom (for example STD/NO and NOO is shown in the figure). Collaboration with theoretical work is an advantage of IR experiment. This made it possible to **find, identify, measure, analyze kinetics and reveal the role in device of them by IR** as summarized in the Table.



We found and identified IR absorptions from NO+$O_{0\text{-}2}$ STD (figure) [6] which showed good agreement with the calculation [7]. LVM of CO+O was established also [8].

In addition to 4atom ring, NN, NO [9] and OO [10] has a **common "chain structure"** which helps understanding of both complexes also. For these works we began constructing IR database [11] and open in a website now.

Table IR absorption of various 4 member rings, observation and calculation

Complex	Experiment		Calculation	
	LVM, cm^{-1},	Author, year, paper	LVM, cm^{-1},	Author, year, paper
CO	526,550,586,742,865,	Newman71RadEff	1154	C.Kaneta90ICPS
	1115		559,565,604,625,925,1141	Jones92PRL
CO+O	1020	Londos20Cryst		Potsidi20Cryst.
NN	766, 963	Abe81MRS	688.6, 918.7	Jones94PRL
			840, 1022	Inoue02ECS
NN+O	801,996, 1027	Wagner88APhysA	671,724,808,861,1070	Jones94SST
			847,1024	Inoue02ECS
NN+2O	810, 1018	Wagner88APhysA	1022	Inoue02ECS
				Fujita06ECS
NO	714,	Inoue18ECS	794, 915	Inoue06MSEB
			722, 801, 1001	Fujita07PhysB
NO+O	736*,	Inoue18ECS	838,915,1025	Inoue06MSEB
			670,794,812,977,1022	Fujita07PhysB
NO+2O	973, 1002	Inoue05SSP,06MSEB		---
ONO(+O)	855	Inoue05SSP	673,720,858,894,1051	Ewels96PRL
			658,751,856,970,1084,	Fujita07PhysB
	(860, 1070LT)	Alt09JAP		

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