Here are definitions of some important technical terms:

- **ACLR** – Adjacent Channel Leakage Ratio. Power ratio of adjacent channel leakage power to the desired signal.
- **ADC, or Analog-to-Digital Converter** – A device that converts a continuous physical quantity (usually voltage) to a digital number.
- **Back-End-of-Line/BEOL**, **Middle of Line/MOL**, and **Front-End-of-Line/FEOL** – In integrated circuit manufacturing, transistors and other active devices are built at the front end of the manufacturing line (FEOL), contacts on the active areas and gates are built at the middle of the manufacturing line (MOL) and the interconnect, or the wiring, is built at the back end of the manufacturing line (BEOL).
- **Bi-Phase On-Off-Keying (BPOOK) –** A modulation scheme of data communication. Carrier amplitude is modulated between zero and one depending on the baseband data. Furthermore, carrier phase is also changed between 0 and 180° when the baseband data is "one". Compared with the OOK and BPSK, the spectrum efficiency is improved and data rate can be doubled with the same spectrum bandwidth. Same as the OOK, envelope detector can be used for demodulation and suited for low power operation.
- **Bi-Phase Shift Keying (BPSK) –** A modulation scheme of data communication. Carrier phase is modulated between 0 and 180° depending on baseband data. Compared with OOK, receiver sensitivity can be improved by using coherent detector because the distance between signal points are large and required signal-to-noise ratio can be relaxed.
- **Body Area Network (BAN)** – Network technologies especially for very small area around a body. Sometimes, used as a synonym of "BCC".
- **Body Channel Communication (BCC)** – Wireless communication technology using electromagnetic transmission through living body.
- **Buck Converter** – is a DC-to-DC power converter which steps down voltage (while stepping up current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS).
- **BLE** – Bluetooth Low Energy. Bluetooth is a wireless standard, and BLE is a Low-Energy (LE) mode in Bluetooth for Smartphone, IoT, etc.
- **Brain Computer Interface (BCI)** – Technologies that retrieve information or intention from brain to use them in computer and other information systems. Various brain measurement methods including electric and optical schemes are applicable for BCI.
- **CC-CV** – Constant Current and Constant Voltage charging. Initially, CC mode is used to pump in large current at varying voltages. When a certain charging level is reached, charging process is switched to CV mode at the ending stages of charging. Most Li-ion batteries employ CC-CV mode of charging.
- **CDS (Correlated Double Sampling)** – Correlated double sampling is a method to cancel the fixed pattern and reset noise in the pixel. During the pixel readout cycle, two sample are taken and subtracted. One signal is taken when the pixel still in the reset state, and the other is taken when the charge has been transferred to the readout node.
- **Chiplet** – It means a tiny chip. Conventionally, multiple cores are mounted in one CPU chip, and multiple functional blocks are mounted in one SoC chip. As the number of cores are increasing, size of one chip also increases. Sometimes increased size causes yield loss, since number of defect is liner to a chip size. Fabricating all necessary functional blocks in one chip with same process node is not necessarily cost effective, since old process node is sometimes good enough to fabricate part of functional blocks. These issues drive the technological development to fabricate multi cores CPU by mounting chiplets in on package and fabricate a system by mounting chiplets of different functions in one package.
- **CMOS image sensor(CIS)** – Image sensors based on the above CMOS manufacturing technology (complementary metal oxide semiconductor). On the other hand, conventional image sensors called CCD (Charge coupled devices) are based on photodiode and poly-gate processes.
- **CMOS/MOS/MOSFET/FET**– Most transistors today are FETs, or field-effect transistors. Most FETs are built with CMOS manufacturing technology (complementary metal oxide semiconductor). Generically they are called MOSFETs, or sometimes MOS transistors.

- **Compound/III-V Semiconductors** – Most semiconductors are silicon-based, but researchers continue to investigate other semiconducting materials with higher electron mobilities because they can be used to make faster devices. The tradeoff is that the materials are harder to work with than silicon. Compound semiconductors are made of two or more elements (e.g. GaAs, InP, GaN, etc.) which are generally found in groups III and V of the periodic table of the elements.
- **DAC or Digital-to Analog Converter –** A device that converts digital data into an analog signal (current, voltage, or electric charge).
- **Dit** – This term stands for interface defect or its density. For MOSFET, Dit generally means the defects between channel and insulating oxide.
- **DNN (Deep Neural Network)** – Neural network that has more than one layer of hidden units between its inputs and its outputs. Famous models include Convolutional Neural Network (CNN) and Recurrent Neural Network (RNN). The idea of realizing higher level functions by a neural network with multiple hidden layers was previously existing, but the convergence in the training using the traditional back propagation method was slow and the performance was insufficient. In recent years, the effectiveness of DNN was rediscovered thanks to the proposal of an effective training algorithm for multilayered neural networks and the significant performance improvement of computers. In addition, DNN has received a great deal of attention at the Image Recognition Contest (ImageNet Large Scale Visual Recognition Challenge) held in 2012 as a result of the overwhelming performance of research teams using DNN. For these reasons, research on utilization of DNN in various fields including image recognition, speech recognition, etc. is currently active. The machine learning algorithm using DNN is called deep learning.
- **DRAM** – Dynamic random access memory stores information as charge on a capacitor that must be periodically refreshed. Dedicated DRAM chips form the bulk of the main memory for typical computers, tablets, and smartphones.
- **ECoG** – Electrocorticography (ECoG) is a type of electrophysiological monitoring that uses electrodes placed directly on the exposed surface of the brain to record electrical activity from the cerebral cortex.
- **Effective Number of Bits (ENOB) –** Measure of the dynamic performance of ADCs, including noise and distortion effect, normalized to the performance of an otherwise ideal ADC with finite resolution.
- **Electroencephalogram (EEG) –** One of electric measurement methods to observe brain activity. Electrodes are placed on scalp or some other parts of the body and electric signals from the brain is amplified and observed. EEG includes both non-invasive and invasive methods.
- **Electro Migration** – High density electron flow moves metal atoms in the interconnect due to momentum exchange between an electron and a metal atom. This phenomenon is called "Electro Migration". In the worst case, this phenomenon causes void and turning into disconnection of the interconnect.
- **EOT or equivalent oxide thickness** – A distance to compare performance of high-k dielectrics with that of SiO_2 film. An SiO_2 film with the thickness of EOT has the same gate capacitance with the high-k material that is used. The higher k dielectrics can reduce EOT, which enhances the MOSFET performance.
- **ESD** – Electrostatic discharge. A sudden release of static electricity between two object caused by contact. If the ESD hits the integrated circuit, it may cause the device to fail or reduce the lifetime.
- **EUV** – Extreme Ultra Violet. It is considered to next generation of light source used in a lithography process. EUV has smaller wave length (13.5 nm) than ArF (193 nm), finite patterning is possible using EUV.
- **EVM** – Error Vector Magnitude. EVM is a measure used to evaluate modulation accuracy of digital transceiver.
- **FD-SOI --** Fully depleted silicon on insulator is a process technology option that can offer speed and power advantages over conventional bulk silicon transistors.
- **FinFET** – A transistor whose 3-D shape resembles a fin, usually with multiple gates surrounding it for better on/off switching control.
- **Front-End/FEOL and Back-End/BEOL** – In integrated circuit manufacturing, transistors and other active devices are built first (at the front end of the manufacturing line or FEOL), while the interconnect, or the wiring, is built afterward, at the "back end" of the manufacturing line (BEOL).

- **f_t/f_{max}** – Cutoff frequency (f_t) and maximum oscillation frequency (f_{max}) are benchmarks of high-frequency performance of transistors. f_t is the frequency when the current gain of transistors becomes unity. f_{max} is the frequency when the unilateral power gain becomes unity. From the view point of circuit performance, f_t tends to be more important for digital logic circuits. On the other hand, f_{max} tends to be more important for high-frequency analog circuits.
- **Gate All Around (GAA) Transistor** – a MOS transistor in which a gate electrode is placed on all four sides of the channel or on all the surface of the wire-shaped channel.
- **Global shutter –** Method of capturing entire scene at single instant in time, rather than by scanning across the scene, like rolling shutter.
  Gm – Transconductance. In MOSFET, Gm is defined as the change in the drain current divided by the small change in the gate/source voltage with a constant drain/source voltage.
  HEMT – High Electron Mobility Transistor, also known as heterostructure FET (HFET) or modulation-doped FET (MODFET). A HEMT is based on a heterojunction which consists of two semiconductors with different band gaps (see also Compound/III-V Semiconductors). By choosing proper materials, the band discontinuity forms high-mobility two-dimensional electron gas at the hetero interface.
- **Hysteretic control** – is a control method for DC-DC converters where a comparator monitors the output voltage and controls the power switch. This method is useful in applications like CPUs and FPGAs where rapid response against load current variation is required.
- **HKMG, or High-k Dielectrics/Metal Gates** – A dielectric is an electrical insulator. "k" is the relative permittivity and is a measure of how well a material will prevent current flow between the gate electrode and the channel region of a field-effect transistor, while capacitively coupling the two to control on/off switching. In future CMOS integrated circuits (chips) the gate dielectric will need to provide capacitive coupling equivalent to that of a silicon-dioxide layer that is just a few atoms thick, to allow the length of the channel region to be scaled down to 10 nm and below. Metal gate materials are more compatible with high-k gate dielectrics than are traditional doped polycrystalline silicon material. Much progress has been made in recent years to integrate metal gates into the CMOS process flow for the manufacture of high-performance chips.
- **HTOL** – High temperature operating life. A reliability test of evaluating life time of semiconductor device operating at actual condition with high temperature. It takes relatively longer time for this test so that the ware-out failure, not initial breakdown, is detected.
- **IEEE 802.11ad –** A standard for ultra-high-speed wireless communication which uses millimeter wave (60GHz band)
- **IGZO** –Acronym for amorphous semiconductor consisting of Indium, Gallium, Zinc, and oxygen.
- **III-V** – see Compound/III-V Semiconductors
- **Instrumentation Amplifier (IA)** – A universal amplifier circuit block based on operational amplifier and some additional devices. It can be used to various measurement applications.
- **Integrated Circuit** – An electrical circuit comprising many interconnected elements (e.g. transistors, diodes, capacitors, resistors, inductors) built on a semiconducting substrate.
- **Interconnect** – The metal lines, or wiring, connecting transistors and other circuit elements. See **Back-End/BEOL**.
- **Interposer** – An electrical interface between chips or between socket and chips. The purpose of an interposer is to connect chips and sockets with different I/O terminals.
- **Known good die (KGD)** – A die which is known as a good die by testing. Sometimes, multiple chips like a logic, a memory, and a communications chips are mounted in one package as one module. If one of chips in a module has a failure, a whole module is classified as a failed and other good chips in a same module will be wasted. To improve the yield of a module and reduce number of wasted chips, it is important to select KGD before integrating chips into a module.
- **Linear Voltage Regulator** – Maintain a steady voltage by changing output resistance according to load current. It requires a higher input voltage than output voltage and normally results in lower efficiency than a switching regulator.
- **Link budget** – A difference between TX power and RX sensitivity, which is a metric for wireless communication range.
- **Low-k Dielectrics/Interconnect** – Interconnect refers to the metal wires that connect elements together in an integrated circuit (chip). The close proximity of adjacent wires can result in

capacitance that can limit chip performance. A low-k dielectric electrically insulates the copper lines while minimizing their mutual capacitance; however, these materials are generally more fragile and thus pose challenges for manufacturing.

- **Magnetic core** – is a piece of magnetic material with a high magnetic permeability used to confine and guide magnetic fields used in devices such as inductors and transformers.
- **MCU** – Microcontroller unit. Microcontrollers typically contain a processor core, memory, and input/output peripherals and are designed for embedded applications.
- **MEMS** – A micro-electro-mechanical system, containing micrometer-scale moving parts.
- **MONOS**– A non-volatile memory element with metal gate-oxide–nitride–oxide–silicon channel multilayer structure. The data or the charges are stored in charge traps in the nitride layer, and the data is read out by the amount of the current flowing through the channel.
- **N(P)BTI** – Negative (Positive) Bias Temperature Instability. The phenomenon happened in PFET (NFET) when negative (positive) bias is continuously applied to the gate and kept with high temperature. The absolute value of threshold voltage increases with bias applied time.
- **Neural Network** – A mathematical model aimed at mimicking the characteristics of brain function by computer simulation. It is composed of an input layer, a hidden layer, an output layer and a wiring connecting each unit. Each wire has a parameter called connecting weight. Units of each layer have a function of inputting data multiplied by connecting weight to data propagating from a number of units of the former layer, and outputting results applied to a predetermined function (activation function). A method of applying a test dataset of input-output pairs and finding a suitable set of connecting weights which gives a target function is called supervised learning. In supervised learning, an algorithm called back propagation is generally used. By applying the set of connecting weights obtained by supervised learning, it is possible to obtain a function which gives desired input-output relation.
- **N-FET/P-FET or NMOS/PMOS** – MOSFETs come in two varieties (n-channel or p-channel) which operate in a complementary fashion.
- **Non-volatile memory (NVM)** – A type of computer memory that retains its stored information even when the power is off.
- **On-Off-Keying (OOK) –** A modulation scheme of data communication. Carrier amplitude is directly modulated between one and zero depending on baseband data. Simple envelope detector can be used for demodulation and suited for low power transceiver.
- **Ovonic Threshold Switch –** A type of two terminals switch which turns on at the exact applied voltage (threshold voltage). It is used as a selector switch of 3 dimensional cross point memory array to suppress unintended leakage from unselected cells.
- **PAM4** – 4-level pulse amplitude modulation. In communication, the data is represented as one of four discrete levels. This means that each symbol can encode two bits of data instead of the conventional 1 bit/symbol. For the same symbol rate and bandwidth, this doubles the data throughput.
- **Phase-Change Memory/PCM** – Phase-change materials have crystalline and non-crystalline states which are used to represent the digits “0” or “1” in a non-volatile memory. Electrical current is used to toggle between the two states – heat from the current causes the material to change its state.
- **Power Efficiency Factor (PEF)** – A metric to characterize amplifiers. It is typically used to compare neural signal amplifiers. It can be used to show how small power consumption the amplifier is, comparing with its performance.
- **Pulse Frequency Modulation (PFM) control** – is a control method where the pulse frequency is changed, being different from pulse width modulation (PWM) control where the frequency is constant and only the pulse width is changed. In DC-DC converters, this control method can achieve better power conversion efficiency in light load conditions than PWM control.
- **Quantum Bit (Qubit)** – In quantum computing, a qubit or quantum bit is a unit of quantum information. A qubit is a two-state quantum-mechanical system.
- **Quantum Dot (QD)** – Very small semiconductor particles, only several nanometers in size, so small that their optical and electronic properties differ from those of larger particles. Quantum dots exhibit properties that are intermediate between those of bulk semiconductors and those of discrete molecules.

- **ReRAM or RRAM** – Resistive random-access memory. A non-volatile random access memory that stores the binary digit by changing the resistivity of material between electrodes.
- **ROI (Region of Interest)** – A ROI is the region which defines the borders of an object under consideration. When capturing the image, individual points of interest can be observed and evaluated.
- **SAR ADC** – A successive approximation ADC is a type of analog-to-digital converter that converts a continuous analog waveform into a discrete digital representation via a binary search through all possible quantization levels before finally converging upon a digital output for each conversion.
- **Scaling/Density/Integration** – Scaling is making transistors and other circuit elements smaller so that more of them will fit on a chip. A denser chip contains more transistors in a given area. Integration is combining circuit elements on a chip to add more functions to achieve lower cost per function.
- **Seebeck effect** – The effect of converting temperature difference between two sides of material into generated voltage difference between two sides of material.
- **Semiconductor** – A material that can be made to conduct or to block the passage of electrical current, giving the ability to store and process information.
- **SER** – Soft Error Rate. When a neutron from space or alpha lay from a package hits a device in a semiconductor chip, charge is generated in a device. This generated charge has possibility to cause flip of stored data. This phenomenon is called soft error and soft error rate is rate at which a semiconductor device encounters.
- **SFDR** – Spurious Free Dynamic Range is a standard metric for analog-to-digital converter and digital-to-analog converter. SFDR indicates in dB the ratio between the powers of the converted main signal and the strongest spurious signal.
- **SNDR** – Signal-to-noise and distortion ratio is a standard metric for analog-to-digital converter and digital-to-analog converter. SNDR indicates in dB the ratio between the powers of the converted main signal and the sum of the noise and the generated harmonic spurs.
- **SoC** – A system-on-a-chip. An integrated circuit which integrates all necessary components of a computer or other electronic system on a single chip.
- **SOI** – A silicon-on-insulator substrate, used to reduce parasitic capacitance and thereby improve integrated circuit performance.
- **Silicon-on-Thin-Box (SOTB)** – A logic transistor process technology in which the body is formed on the thin buried oxide. SOTB devices have advantages such as small Vth variation and low Vdd operation with dopant-less channel structure by Box (buried oxide) layer, contributing to energy reduction of logic circuits.
- **Strained silicon & SiGe stressors** – Silicon is said to be "strained" when its atoms are pulled farther apart or closer together than normal. Doing so alters the ease with which electrons flow through the silicon, enabling transistors built with it to operate faster and /or at lower voltage. The external **stressors** which impart strain are materials with slightly different atomic spacing than silicon. For example, a common way to compressively strain the channel region of a p-channel silicon field-effect transistor is to embed silicon-germanium (**SiGe**), which has larger atomic spacing than does Si, in its source and drain regions.
- **SRAM** – A type of computer memory (static random access memory) that uses six or more transistors to store each bit of information. It can be written to and read from very quickly.
- **SS** – Subthreshold Swing. SS is defined as a reciprocal value of a logarithmic slope in MOSFET Id-Vg characteristics. A smaller SS is better in device switching. The unit is given as [mV/dec], and 60 is a theoretical minimum value in the conventional MOSFETs at room temperature.
- **STT-MRAM** – Spin torque transfer magnetic random access memory is an emerging type of non-volatile memory that operates according to the "spin" state of electrons, not their electric charge. STT-MRAMs can be made extremely small.
- **TDC, or Time-to-Digital Converter** – A device for recognizing events and providing a digital representation of the time they occurred.
- **Ternary content-addressable memory (TCAM) –** Content-addressable memory is a specialized memory capable of searching a word in the entire contents. "Ternary" refers to capability of storing and querying "X" don't care, in addition to 0 and 1.

- **Time-of-Flight (ToF) ranging system/method** – A system/method that measures a distance by measuring a period from a signal launch time to its detection by reflected by an object. In image sensor based systems, the signal is light pulses. In ToF CIS systems, since all pixels must be synchronously driven to the light sources, the global shutter function is indispensable.
- **Transistor** – A tiny electrical switch that serves as the building block for integrated circuits. It has no moving parts and is made with a semiconductor material, usually silicon. Transistors can be ganged together by the billions on chips and programmed to receive, process and store information, and to output information and/or control signals.
- **TSV** – Through silicon vias. TSVs provide a connection from the top to the bottom of a silicon die, allowing vertical interconnections for 3-D stacking of dies.
- **UWB** – Ultra-wideband radio is wireless communication that operates in the 3.1-10.6 GHz band using a minimum of 500MHz of bandwidth, typically with very low average radiated power density.
- **2T-MONOS** – A memory consisting of a MONOS-structure memory element and a select transistor. (see MONOS.)
- **2.5D, 3D Integration** – Both are packaging technique to integrate multiple chips in one package. In 3D integration, multiple chips are stacked in vertical direction and these chips are electrically connected by micro-bumps and TSV. This technique is actually used in DRAM stacking and CMOS image sensor/control logic chip stacking. The technical challenges are that chips in a stack are suffered from heating of a high performance chip, and TSV should be formed in each chip. In 2.5D integration, an interposer made of silicon or resin with interconnect structure is prepared. Chips are mounted on an interposer in a horizontal direction. By using this technique, heating issue is reduced and TSV does not need to be formed in each chip.