



**TERADAR**

Healthcare

**Unlocking Safe Skin Cancer  
Detection Through the  
Promise of Terahertz Imaging**

## Executive Summary

Skin cancer remains one of the most prevalent and costly cancers worldwide, affecting millions each year and straining medical systems through high biopsy rates and delayed detection. Early identification is crucial, yet existing diagnostic imaging techniques are either invasive, ionizing, or prohibitively expensive.

Teradar's terahertz imaging technology offers an innovative approach: safe, high-resolution, non-ionizing imaging that distinguishes healthy and cancerous tissue based on minute electromagnetic differences.

This paper explores the physical principles of terahertz waves, the emerging body of scientific evidence supporting their medical potential, and how Teradar's advancements, initially developed for automotive and defense applications, could redefine early detection and diagnostic precision in dermatology and oncology.

### The Problem: Safe, Accessible, and Accurate Skin Diagnostics

Globally, skin cancer is diagnosed in more than 1.5 million new cases annually. The dominant technique today is visual inspection followed by biopsy, which relies heavily on a physician's observational skills and subjective judgment. Advanced imaging tools such as MRI and CT scans provide precision but involve ionizing radiation, complex facilities, and are expensive.

Dermatologists and oncologists face three significant challenges:

- **Safety:** repeated imaging using ionizing or photonic energy can introduce cumulative risk, especially in pediatric or high-risk patients.
- **Access:** developing regions often lack imaging infrastructure, resulting in later-stage diagnoses.
- **Cost:** biopsies, lab analysis, and follow-ups raise costs significantly while causing unnecessary anxiety for patients.

Teradar's terahertz imaging, leveraging sub-millimeter electromagnetic waves, offers a path toward safe, compact, and accessible imaging systems for clinics worldwide.

### Terahertz Fundamentals: The Invisible Frontier

The terahertz region of the electromagnetic spectrum lies between microwaves and infrared light, spanning **0.1 to 10 THz** and corresponding to wavelengths of **3 mm to 30  $\mu\text{m}$** .

What makes this range exceptional for medical imaging is a combination of factors:

- **Non-ionizing energy:** Unlike X-rays, terahertz photons carry only millielectronvolts of energy, which are insufficient to disrupt DNA or chemical bonds.
- **Sensitivity to water content:** Biological tissue contrast arises from variations in hydration, and terahertz frequencies are highly responsive to these changes.
- **Sub-millimeter resolution:** Terahertz imaging can resolve fine structural features beneath the skin surface, matching or exceeding ultrasound precision for superficial tissues.

These properties enable terahertz sensing to reveal hidden morphological information, such as cellular density, hydration, and changes in protein structure, without harming tissue or requiring dyes or contrast agents.

### **Discovering Skin Cancer Through Terahertz Signatures**

Recent experimental studies show that terahertz imaging can accurately differentiate between healthy epidermal tissue and basal cell carcinoma by analyzing variations in refractive index and absorption coefficients.

Cancerous tissues tend to exhibit higher water content and denser molecular structures, leading to distinctive terahertz reflectivity patterns.

Key breakthroughs:

- A biosensor developed at Queen Mary University and the University of Glasgow detected skin cancer with remarkable accuracy, leveraging tiny asymmetric resonators on flexible substrates to analyze changes in resonance frequency and transmission.
- A handheld terahertz imaging prototype demonstrated early-stage cancer detection through hydration mapping, forming images by capturing the reflected terahertz field to highlight abnormalities.
- In vivo imaging studies have confirmed terahertz's ability to visualize tumor margins beneath the skin, aiding surgical planning and reducing the risk of recurrence.

### **Potential to Impact Healthcare**

If commercialized and scaled, terahertz imaging could transform dermatology and oncology:

- **Early Detection:** Detecting subtle structural or hydration anomalies before malignancy becomes visually apparent.

- **Non-invasive:** Avoiding the pain, risk, and cost of repeated biopsies.
- **Accessible Devices:** Compact, affordable systems deployable in dermatology offices and low-resource settings.
- **Surgical Precision:** Intraoperative imaging to define tumor boundaries with sub-millimeter accuracy.

Teradar's Modular Terahertz Engine (MTE) was originally engineered for high resolution automotive-grade sensing, however, this technology is uniquely positioned for medical applications that demand accuracy, stability, in a compact form factor.

## The Physics of Terahertz

Terahertz waves interact with polar molecules such as water via dipole moment oscillations, so minute hydration changes alter the local dielectric constant. By analyzing reflected and transmitted terahertz signals, Teradar's technology can construct a spatial map of skin structure and pathology.

Core principles:

- **Time-Domain Spectroscopy (TDS):** Measures the phase and amplitude of terahertz pulses to reconstruct material properties.
- **Frequency-Domain Imaging:** Captures continuous-wave reflections to generate hyperspectral data revealing biochemical variations.
- **Dielectric Profiling:** Enables discrimination of tissue based on water, lipid, and protein ratios, parameters strongly correlated with malignancy.

These imaging modalities mirror the functionality of radar systems, yet at frequencies 1,000 times higher, enabling micron-scale depth resolution.

## Safety and Regulatory Considerations

Unlike X-rays or CT scans, terahertz imaging uses non-ionizing radiation. Studies have shown that exposure within 0.1–10 THz range and intensities below 1 mW/cm<sup>2</sup> do not damage tissue.

## From Laboratory to Clinic

Translating terahertz imaging into routine clinical use requires overcoming several engineering barriers:

- **Compact Source Development:** Miniaturizing photoconductive antennas and quantum cascade lasers into affordable, handheld systems.
- **Detector Sensitivity:** Enhancing signal-to-noise ratios to capture faint reflections from soft tissue.

- **Data Processing:** Leveraging AI-driven segmentation and machine learning to interpret terahertz spectra and morphology in real time.

Teradar's years of innovation in signal processing, modular architecture, and electromagnetic design, honed in the autonomous driving sector, directly address these technical challenges. The company's Modular Terahertz Engine could be adapted for scalable medical imaging devices, enabling integration into existing clinical diagnostic workflows.

### **Making Global Accessibility a Reality**

By removing reliance on ionizing radiation, large-scale cooling systems, or radiology infrastructure, terahertz imaging could revolutionize access to precision healthcare globally. Portable terahertz scanners could serve remote clinics, humanitarian missions, and field hospitals. When combined with cloud-connected analysis, physicians anywhere could obtain expert dermatologic imaging assessments without expensive capital investment.

For developing regions, this could represent the next major leap: safe, low-cost, AI-enhanced medical imaging for all.

### **Broader Biomedical Horizons**

Beyond skin cancer, terahertz imaging shows promise across multiple frontiers:

- **Burn assessment and wound healing monitoring**, where hydration and tissue recovery can be quantified non-invasively.
- **Oral and cervical cancer detection**, benefiting from the high contrast between normal and neoplastic epithelium.
- **Pharmaceutical quality control**, ensuring precise structural integrity in biologics and drug delivery mechanisms.

Each of these domains leverages the same core advantage: terahertz's unique ability to map molecular composition at microstructure resolution without ionization or invasive sampling.

### **Investment Perspective**

For investors and medtech innovators, Teradar's expansion into biomedical imaging represents a convergence of scientific validation and market opportunity:

- Skin cancer diagnostics alone represent a \$7.9B global market opportunity, growing at double digits annually through 2030.

- Regulatory alignment and safety groundwork by IEC and FDA agencies is paving the way for first-generation THz medical systems by 2027.
- Platform scalability means Teradar’s foundational technology, originally tested under automotive-grade reliability, can transition to healthcare with reduced R&D risk.

Early investment in this cross-sector innovation could position stakeholders at the forefront of a diagnostic revolution on a scale similar to the shift from analog X-ray to digital radiography decades ago.

## **A Better Path Forward**

To realize this vision, Teradar may explore collaborating with research institutions and medical centers to conduct controlled clinical pilots focused on:

- **Comparative imaging** of known carcinoma sites.
- **Performance benchmarking** versus optical coherence tomography and ultrasound.
- **Development of AI-guided interpretive algorithms** to automate lesion classification.

By merging terahertz science with digital diagnostics and miniaturized electronics, the company could create a new standard for safe, intelligent skin imaging for physicians worldwide.

## **Conclusion: A New Spectrum for Human Health**

For decades, the terahertz domain was considered the “last unexplored gap” in the electromagnetic spectrum, too high for electronics, and too low for photonics. Today, that frontier is being crossed, and Teradar is leading the charge.

The ability to detect, quantify, and visualize biological changes non-invasively could reshape how skin cancer, and ultimately other diseases, are diagnosed, managed, and prevented. Much of this remains research in progress, yet every discovery affirms the extraordinary potential of terahertz technology to make the invisible visible, safely and affordably.

Where automotive and defense applications first proved Teradar’s durability and resolution, healthcare can become a meaningful application, a future where light beyond the visible saves lives.

**References:**

Data and technical context drawn from peer-reviewed and institutional sources on terahertz imaging and skin cancer detection.

**ecancer**

<https://ecancer.org/en/news/24261-terahertz-biosensor-detects-skin-cancer-with-remarkable-accuracy-ushering-in-new-era-of-early-detection>

[Terahertz biosensor detects skin cancer with remarkable ... - ecancer](#)

[Researchers have developed a revolutionary biosensor using terahertz \(THz\) waves that can detect skin cancer with exceptional sensitivity, potentially paving th](#)

**Syntecoptics**

<https://syntecoptics.com/terahertz-imaging-system-detection-skin-cancer-detection/Terahertz-Imaging-System-For-Early-Skin-Cancer-Detection>

[A physicist is developing a new method for skin cancer screening and diagnosis using Terahertz Imaging System. Terahertz waves are safe and can detect changes in skin hydration, which can indicate cancer. The researcher is building a handheld device that can be used in clinical settings. The researchers discuss the potential of terahertz waves for \[..\]](#)

**eureka**

<https://eureka.patsnap.com/report-terahertz-imaging-in-medical-settings-regulatory-and-safety-pathways>

[Terahertz Imaging In Medical Settings: Regulatory And Safety ...](#)

[Explore the evolution of terahertz imaging from laboratory curiosity to promising medical diagnostic tool for cancer detection, dental diagnostics, and wound assessment.](#)